REPORT NUMBER: GTR20-MGA-20-002

National Highway Traffic Safety Administration
(NHTSA)
GTR 20 Electric Vehicle Safety Tests

Tesla, Inc.
2020 Telsa Model 3 Standard Range 4-Door Sedan
NHTSA No.: M20205000

MGA RESEARCH CORPORATION
5000 Warren Road
Burlington, WI 53105

Final Report Date: April 4, 2022

FINAL REPORT

U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crashworthiness Standards
1200 New Jersey Ave, SE
Room W43-410
Washington, DC 20590

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Division Chief, New Car Assessment Program
NHTSA, Office of Crashworthiness Standards

Date: _____

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NHTSA, Office of Crashworthiness Standards

Date: _____

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15. Supplementary Notes		

16. Abstract

Global Technical Regulation (GTR) 20 Electric Vehicle Safety evaluations were conducted on the subject 2020 Tesla Model 3 Standard Range 4-Door Sedan in accordance with the specifications of the following GTR 20 Electric Vehicle Safety sections:

- 5.1.1 – Protection against electric shock
- 5.1.2 – Functional Safety
- 5.3.2 – Warning in the event of operational failure of vehicle controls that manage REESS safe operation
- 5.3.3 – Warning in the case of a thermal event within the REESS
- 5.3.4 – Warning in the event of low energy content of REESS
- 5.4.5 – External short circuit protection
- 5.4.6 – Overcharge protection
- 5.4.7 – Over-discharge protection
- 5.4.8 – Over-temperature protection
- 5.4.9 – Overcurrent protection

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SECTION 1
PURPOSE OF THE TEST

Global Technical Regulation (GTR) 20 for Electric Vehicle Safety was established in the Global Registry on March 14, 2018. After publication of GTR 20, NHTSA began work evaluating the requirements of the GTR by creating a draft laboratory test procedure and carrying out testing on a subject electric vehicle.[1] As a result of this first vehicle evaluation, NHTSA updated the laboratory test procedure and proceeded to test additional electric vehicles to continue to evaluate the feasibility and objectivity of the tests in GTR 20. This report covers testing and results of one of those additional electric vehicles.

GTR 20 Electric Vehicle Safety "in-use" evaluations were conducted on the subject Tesla Model 3 Standard Range 4-Door Sedan. The following evaluations were conducted:

- 5.1.1 – Protection against electric shock
- 5.1.2 – Functional Safety
- 5.3.2 – Warning in the event of operational failure of vehicle controls that manage rechargeable electric energy storage system (REESS) safe operation
- 5.3.3 – Warning in the case of a thermal event within the REESS
- 5.3.4 – Warning in the event of low energy content of REESS
- 5.4.5 – External short circuit protection
- 5.4.6 – Overcharge protection
- 5.4.7 – Over-discharge protection
- 5.4.8 – Over-temperature protection
- 5.4.9 – Overcurrent protection

These evaluations were conducted in accordance with the NHTSA Laboratory Test Procedure for GTR 20 Electric Vehicle Safety Rev. 01 dated May 13, 2020. This test procedure is attached as Appendix D.

[1] See report DOT HS 812 092 in docket NHTSA-2021-0029

SECTION 2
SUMMARY OF THE TEST RESULTS

Electric Vehicle GTR 20 “in-use” Evaluations were performed by MGA Research Corporation on a subject 2020 Tesla Model 3 Standard Range 4-Door Sedan. The vehicle was evaluated for protection against electrical shock and functional safety. The REES was evaluated for functionality and safety in-use.

Based on the test results, 2020 Tesla Model 3 Standard Range 4-Door Sedan appears to meet the requirements for the evaluations that were conducted.

Data sheets, along with pre-test and post-test photographs, are included in this report to document the test.

SECTION 3
VEHICLE INFORMATION / DATA SHEETS

DATA SHEET NO. 1
TEST VEHICLE SPECIFICATIONS

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

TEST VEHICLE INFORMATION

Year/Make/Model/Body Style	2020 Tesla Model 3 4-Door Sedan
NHTSA No.	M20205000
Color	Deep Blue Metallic
Odometer Reading	5 mi

DATA FROM CERTIFICATION LABEL

Manufactured By	Tesla, Inc
Date of Manufacture	03/20
VIN:	5YJ3E1EA2LF705779

GVWR (kg)	2060
GAWR Front (kg)	1110
GAWR Rear (kg)	1257

ELECTRIC VEHICLE PROPULSION SYSTEM

Type of Electric Vehicle (Electric/Hybrid):	Electric
Electric Energy Storage/Device:	Lithium Ion
Nominal Voltage (V):	350
Is this vehicle equipped with an Automatic Propulsion Battery Disconnect?	Yes
Physical Location of the Automatic Propulsion Battery Disconnect:	Internal to the Battery Pack System
Auxiliary Battery Type:	Lead Acid

DATA SHEET NO. 1 (CONTINUED)
GENERAL TEST AND VEHICLE PARAMETER DATA

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

ELECTRIC ENERGY STORAGE CONVERSION/DEVICE SYSTEM DATA (COTR SUPPLIED)

Electrolyte Fluid Type:	Organic Electrolyte	
Electrolyte Fluid Specific Gravity:	1.2 g/cc	
Electrolyte Kinematic Viscosity:	2.6 mPa s	
Electrolyte Fluid Color:	Clear	
Electric Energy Storage/Conversion System Coolant Type, Color, Specific Gravity (if applicable):	G48 Ethylene Glycol Light Blue 1.122 / 1.0	
Location of Battery Modules:		Inside Passenger Compartment
	X	Outside Passenger Compartment
	The high-voltage battery is located below the occupant compartment.	

ELECTRIC ENERGY STORAGE CONVERSION/DEVICE STATE OF CHARGE

For all battery types:	
Voltage range corresponding to **useable energy** of the battery:	
Minimum State of Charge:	240 V
Maximum State of Charge:	403 V
95% of Maximum State of Charge:	400 V
For batteries that are rechargeable ONLY by an energy source on the vehicle:	
Voltage range corresponding to **useable energy** of the battery:	
Minimum State of Charge:	
Maximum State of Charge:	

DATA SHEET NO. 2
PROTECTION AGAINST ELECTRICAL SHOCK

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

PROTECTION AGAINST DIRECT CONTACT
(GTR 20 Section 5.1.1.1.) (NHTSA TP Section 2.1A)

PASSENGER AND LUGGAGE COMPARTMENT

Applicable HV Locations Present: **NO** (if YES fill out table below)

HV Location	Voltage	Continuity

AREAS OTHER THAN THE PASSENGER AND LUGGAGE COMPARTMENT

Applicable HV Locations Present: **NO** (if YES fill out table below)

HV Location	Voltage	Continuity

DATA SHEET NO. 2 (CONTINUED)
PROTECTION AGAINST ELECTRICAL SHOCK

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

SERVICE DISCONNECT

HV Location	Voltage	Continuity
Internal to the high voltage battery pack	N/A	N/A

MARKINGS

HV Location	Marking	Orange Cover
Compressor Cable		X
Charger Port to REESS Cable		X
REESS to Rear Motor Cable		X
REESS “Penthouse” Cover	X	

DATA SHEET NO. 2 (CONTINUED)
PROTECTION AGAINST ELECTRICAL SHOCK

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

PROTECTION AGAINST INDIRECT CONTACT
(GTR 20 Section 5.1.1.2.) (NHTSA TP Section 2.1B)

Applicable HV Locations Present: **YES/NO** (if YES fill out table below)

HV Location	Connection	Resistance
REESS “Penthouse” Cover	Bolts	0.00 Ω

Applicable HV Locations < 2.5 m Apart Present: **NO** (if YES fill out table below)

HV Location 1	HV Location 2	Resistance

DATA SHEET NO. 2 (CONTINUED)
PROTECTION AGAINST ELECTRICAL SHOCK

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

GROUNDED EXTERNAL CHARGING

External Power Supply Grounding Method	Ground is a part of the charging cable, pin #3 on OEM provided charging cable.

ISOLATION RESISTANCE – DC BUS

Measurement	Value	Isolation
Vb	377.8 V	
V1	219.0 V	5,042,426 Ω
V2	133.9 V	4,744,141 Ω
V1’	14.3 V	
V2’	14.5 V	
Ro	218,600 Ω	
Working Voltage	403.2 V	11,766 Ω/V

ISOLATION RESISTANCE – AC BUS

Measurement	Value	Isolation
Vb		
V1		
V2		
V1’		
V2’		
Ro		
Working Voltage		

DATA SHEET NO. 2 (CONTINUED)
PROTECTION AGAINST ELECTRICAL SHOCK

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

ISOLATION MONITORING SYSTEM FOR FUEL CELL VEHICLES

Calculated Isolation Resistance	Resistor	Indication to Driver

ISOLATION RESISTANCE – EXTERNAL AC CHARGING

Measurement	Value	Isolation
Vb	378.1 V	
V1	175.8 V	4,560,822 Ω
V2	156.4 V	4,685,963 Ω
V1’	14.6 V	
V2’	14.1 V	
Ro	218,600 Ω	
DC Working Voltage	403.2 V	11,312 Ω/V
AC Working Voltage		

DATA SHEET NO. 3
FUNCTIONAL SAFETY

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

MOMENTARY INDICATION WHEN PLACED IN ACTIVE DRIVING MODE
(GTR Section 5.1.2.1.) (NHTSA TP Section 2.2A)

Internal Combustion Engine Provides Propulsion Power Upon Startup:
NO (if NO fill out table below)

Drive Mode Selection	Momentary Indication Description
Startup	Vehicle Ready Light illuminates upon startup.
Drive / Forward	Drive direction icon on instrument cluster changes from “P” to “D”.
Reverse	Drive direction icon on instrument cluster changes from “P” to “R”.

DRIVER TO BE INFORMED WHEN LEAVING VEHICLE
(GTR 20 Section 5.1.2.2.) (NHTSA TP Section 2.2B)

Driver Can Leave Vehicle While In Active Driving Mode: **NO** (if YES fill out table below)

Drive Mode Selection	Momentary Indication Description
Drive / Forward	Warning message “Driver’s door open. Proceed with caution.” Vehicle changes to “P” position when brake pedal is released.
Reverse	Warning message “Driver’s door open. Proceed with caution.” Vehicle changes to “P” position when brake pedal is released.

DATA SHEET NO. 3 (CONTINUED)
FUNCTIONAL SAFETY

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

STATE OF DRIVE DIRECTION IDENTIFICATION
(GTR 20 Section 5.1.2.3.) (NHTSA TP Section 2.2C)

Drive Mode Selection	Momentary Indication Description
Drive / Forward	Drive direction icon on instrument cluster changes from “P” to “D”.
Reverse	Drive direction icon on instrument cluster changes from “P” to “R”.

VEHICLE MOVEMENT WHILE EXTERNALLY CHARGING
(GTR 20 Section 5.1.2.4.) (NHTSA TP Section 2.2D)

Vehicle Equipped with External Charging: **YES** (if YES fill out table below for each charger type)

Part Number: Gen 2 Mobile Connector

Drive Mode Selection	Vehicle Movement
Drive / Forward	None
Reverse	None

Drive Mode Selection	Vehicle Movement
Drive / Forward	
Reverse	

Drive Mode Selection	Vehicle Movement
Drive / Forward	
Reverse	

DATA SHEET NO. 4
FUNCTIONALITY OF REESS IN A VEHICLE

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

WARNING IN THE EVENT OF OPERATIONAL FAILURE OF VEHICLE CONTROLS THAT MANAGE THE SAFE OPERATION OF THE REESS
(GTR 20 Section 5.3.2.) (NHTSA TP Section 2.3A)

Description of Warning to the Driver	Warning provided to the operator in the common message space of the instrument cluster. Information provided by vehicle manufacturer in TEST VEHICLE INFORMATION FOR HYBRID AND ELECTRIC VEHICLES (for GTR 20) form.

WARNING IN THE EVENT OF A THERMAL EVENT WITHIN THE REESS
(GTR 20 Section 5.3.3.) (NHTSA TP Section 2.3B)

Description of Warning to the Driver	Warning provided to the operator in the common message space of the instrument cluster. “Vehicle system temperature high”, accompanied by a single chime. Information provided by vehicle manufacturer in TEST VEHICLE INFORMATION FOR HYBRID AND ELECTRIC VEHICLES (for GTR 20) form.

WARNING IN THE EVENT OF LOW ENERGY CONTENT OF REESS
(GTR 20 Section 5.3.4.) (NHTSA TP Section 2.3C)

Description of Warning to the Driver	Warning provided to the operator in the common message space of the instrument cluster. “Battery charge level low”, “Charge now”, accompanied by a single chime. Warning triggered at low state of charge, monitored by the battery management system. Information provided by vehicle manufacturer in TEST VEHICLE INFORMATION FOR HYBRID AND ELECTRIC VEHICLES (for GTR 20) form and observed in testing.

DATA SHEET NO. 5
EXTERNAL SHORT CURCUIT

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

EXTERNAL SHORT CIRCUIT SETUP
(GTR 20 Section 5.4.5.) (NHTSA TP Section 2.4A)

Test Setup Notes	The subject vehicle was connected to an external short circuit contactor through the breakout harness. The breakout harness was attached to the high voltage bus at the DC Link Connection under the penthouse cover. The total external resistance of the test setup was 4.6 mΩ.

ISOLATION RESISTANCE – EXTERNAL SHORT CIRCUIT

Measurement	Value	Isolation
Vb	0.0 V	
V1	0.0 V	
V2	0.0 V	
V1’	0.0 V	
V2’	0.0 V	
Ro	218,600 Ω	
DC Working Voltage	403.2 V	
AC Working Voltage		

EXTERNAL SHORT CIRCUIT OBSERVATIONS

Post Test Observations	The test was concluded when current was no longer present across the external short circuit. The vehicle was no longer operational after the test, and no standard cycle was performed. Vehicle was returned to operation with the replacement of a relay/fuse in the REESS. The vehicle was observed for one hour and there was no evidence of electrolyte leakage, rupture, venting, fire or explosion.

DATA SHEET NO. 6
OVERCHARGE PROTECTION

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

OVERCHARGE PROTECTION SETUP
(GTR 20 Section 5.4.6.) (NHTSA TP Section 2.4B)

Test Setup Notes	The subject vehicle state of charge was adjusted to approximately 95%. A battery test system was connected to the vehicle through the breakout harness. The breakout harness was attached to the high voltage bus at the DC Link Connection under the penthouse cover. The battery test system was programmed to supply a 10A charging current.

ISOLATION RESISTANCE – OVERCHARGE

Measurement	Value	Isolation
Vb	405.8 V	
V1	215.8 V	5,026,862 Ω
V2	144.3 V	4,997,996 Ω
V1’	14.6 V	
V2’	14.2 V	
Ro	218,600 Ω	
DC Working Voltage	403.2 V	12,396 Ω/V
AC Working Voltage		

OVERCHARGE PROTECTION OBSERVATIONS

Post Test Observations	Charge was terminated by the vehicle, concluding the test. A standard cycle was performed immediately following the test. The vehicle was observed for one hour and there was no evidence of electrolyte leakage, rupture, venting, fire or explosion.

DATA SHEET NO. 7
OVER-DISCHARGE PROTECTION

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

OVER-DISCHARGE PROTECTION SETUP
(GTR 20 Section 5.4.7.) (NHTSA TP Section 2.4C)

Test Setup Notes	The subject vehicle state of charge was adjusted to approximately 10%. A battery test system was connected to the vehicle through the breakout harness. The breakout harness was attached to the high voltage bus at the DC Link Connection under the penthouse cover. The battery test system was programmed to draw a 10A of discharging current.

ISOLATION RESISTANCE – OVER-DISCHARGE

Measurement	Value	Isolation
Vb	260.5 V	
V1	112.9 V	4,458,579 Ω
V2	125.7 V	4,907,301 Ω
V1’	10.6 V	
V2’	9.8 V	
Ro	218,600 Ω	
DC Working Voltage	403.2 V	11,058 Ω/V
AC Working Voltage		

OVER-DISCHARGE PROTECTION OBSERVATIONS

Post Test Observations	Discharge was terminated by the vehicle, concluding the test. A standard cycle was performed immediately following the test. The vehicle was observed for one hour and there was no evidence of electrolyte leakage, rupture, venting, fire or explosion.

DATA SHEET NO. 8
OVER-TEMPERATURE PROTECTION

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

OVER-TEMPERATURE PROTECTION SETUP
(GTR 20 Section 5.4.8.) (NHTSA TP Section 2.4D)

Test Setup Notes	The subject vehicle state of charge was adjusted to approximately 95% and environmentally conditioned to 45°C prior to the test. The active cooling was disabled following vehicle manufacturer instructions to remove power to the compressor. The vehicle was installed on a chassis dynamometer and a driving cycle alternating between acceleration to 80mph and coasting to 15mph was performed.

ISOLATION RESISTANCE – OVER-TEMPERATURE

Measurement	Value	Isolation
Vb	372.3 V	
V1	185.4 V	5,111,545 Ω
V2	136.1 V	4,848,494 Ω
V1’	12.8 V	
V2’	13.1 V	
Ro	218,600 Ω	
DC Working Voltage	403.2 V	12,025 Ω/V
AC Working Voltage		

OVER-TEMPERATURE PROTECTION OBSERVATIONS

Post Test Observations	Vehicle power was reduced approximately 10 minutes after the start of the test and the REESS temperature stabilized with a gradient of less than 4°C, through a 2-hour period, which concluded the test. There was no evidence of electrolyte leakage, rupture, venting, fire or explosion.

DATA SHEET NO. 9
OVERCURRENT PROTECTION

Test Vehicle: 2020 Tesla Model 3 4-Door Sedan NHTSA No.: M20205000

OVERCURRENT PROTECTION SETUP
(GTR 20 Section 5.4.9.) (NHTSA TP Section 2.4E)

Test Setup Notes	The subject vehicle state of charge was adjusted to approximately 50%. The vehicle was connected to a DC Fast Charger. A battery test system was connected to the vehicle through the breakout harness. The breakout harness was attached to the high voltage bus at the DC Link Connection under the penthouse cover. After charge was initiated through the DC Fast Charger, the battery test system was programmed to supply additional charging current.

ISOLATION RESISTANCE – OVERCURRENT

Measurement	Value	Isolation
Vb	365.7 V	
V1	191.2 V	4,911,952 Ω
V2	127.4 V	4,852,240 Ω
V1’	13.2 V	
V2’	12.9 V	
Ro	218,600 Ω	
DC Working Voltage	403.2 V	12,034 Ω/V
AC Working Voltage		

OVERCURRENT PROTECTION OBSERVATIONS

Post Test Observations	Charge was terminated by the vehicle, concluding the test. A standard cycle was performed immediately following the test. The vehicle was observed for one hour and there was no evidence of electrolyte leakage, rupture, venting, fire or explosion.

APPENDIX A
PHOTOGRAPHS

TABLE OF PHOTOGRAPHS

Photo No. 001 - As Delivered Left Front Three Quarter View of Test Vehicle

Photo No. 002 - As Delivered Left Rear Three Quarter View of Test Vehicle

Photo No. 003 - External Vehicle Charger

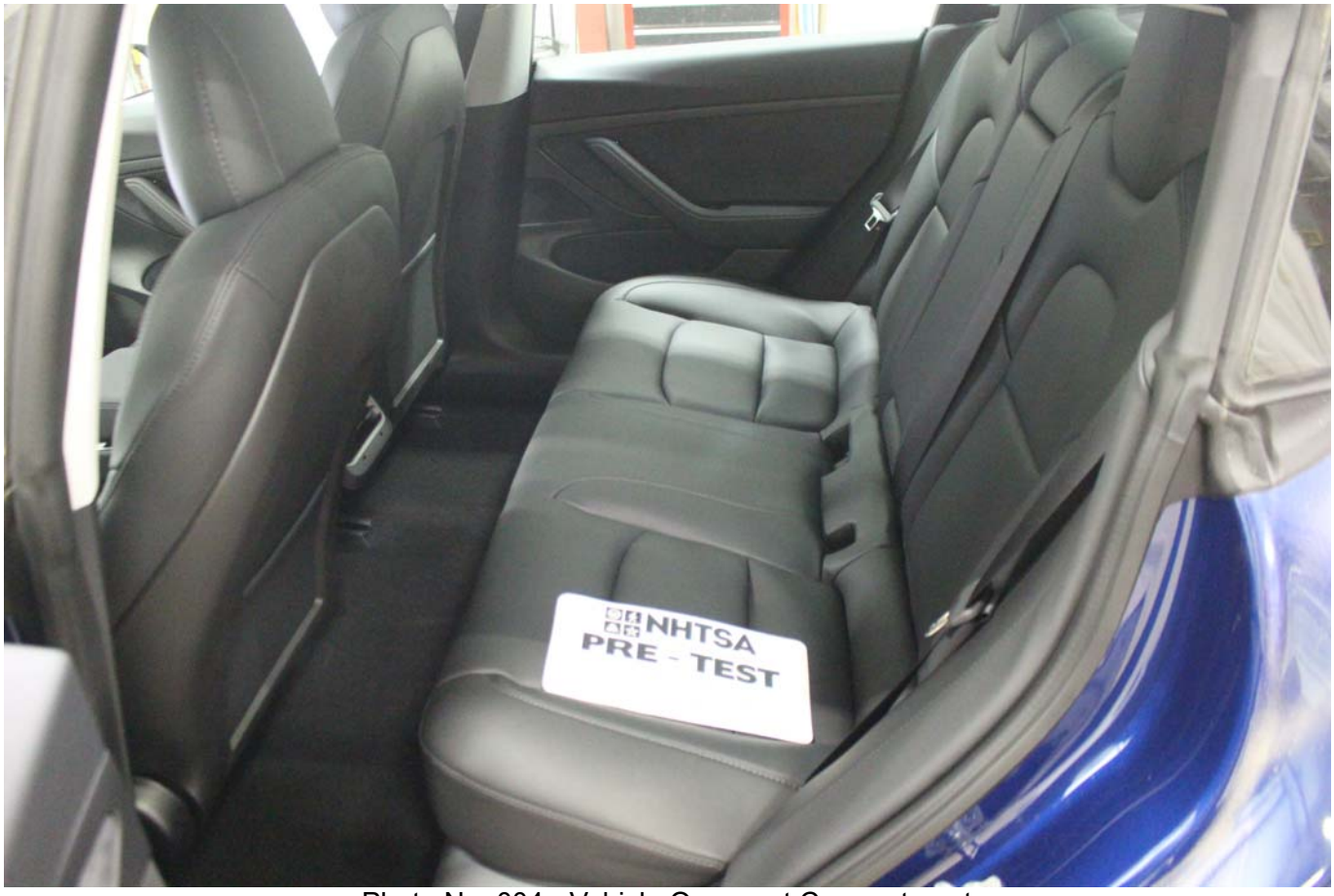


Photo No. 004 - Vehicle Occupant Compartment

Photo No. 005 - Vehicle Occupant Compartment with Components Removed

Photo No. 006 - Vehicle Luggage Compartment

Photo No. 007 - Vehicle Luggage Compartment with Components Removed

PHOTOGRAPH NOT APPLICABLE

Photo No. 008 - Vehicle Manual Safety Disconnect Installed in Vehicle

PHOTOGRAPH NOT APPLICABLE

Photo No. 009 - Vehicle Manual Safety Disconnect Removed from Vehicle

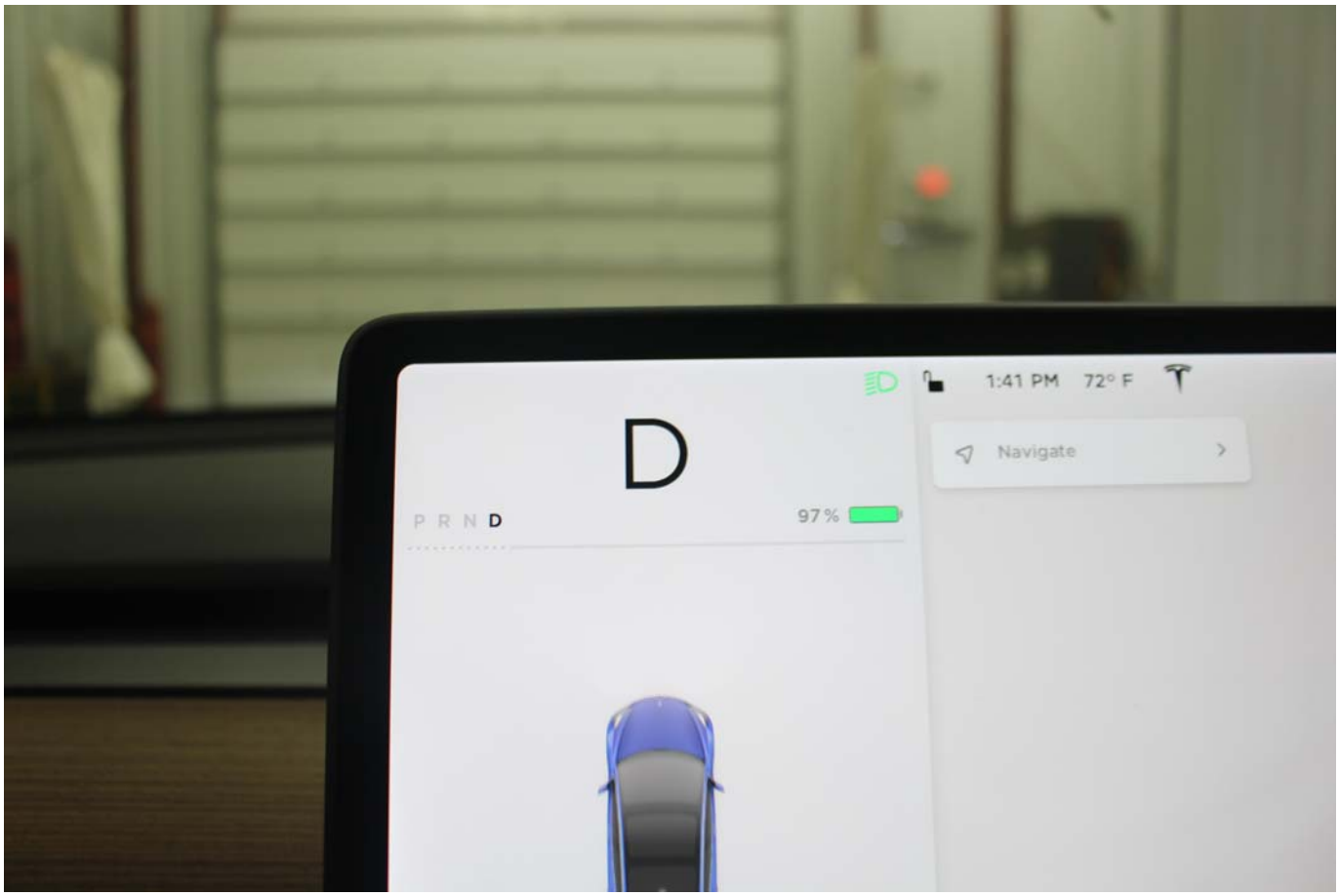


Photo No. 010 - Momentary Indication When Placed in Active Driving Mode

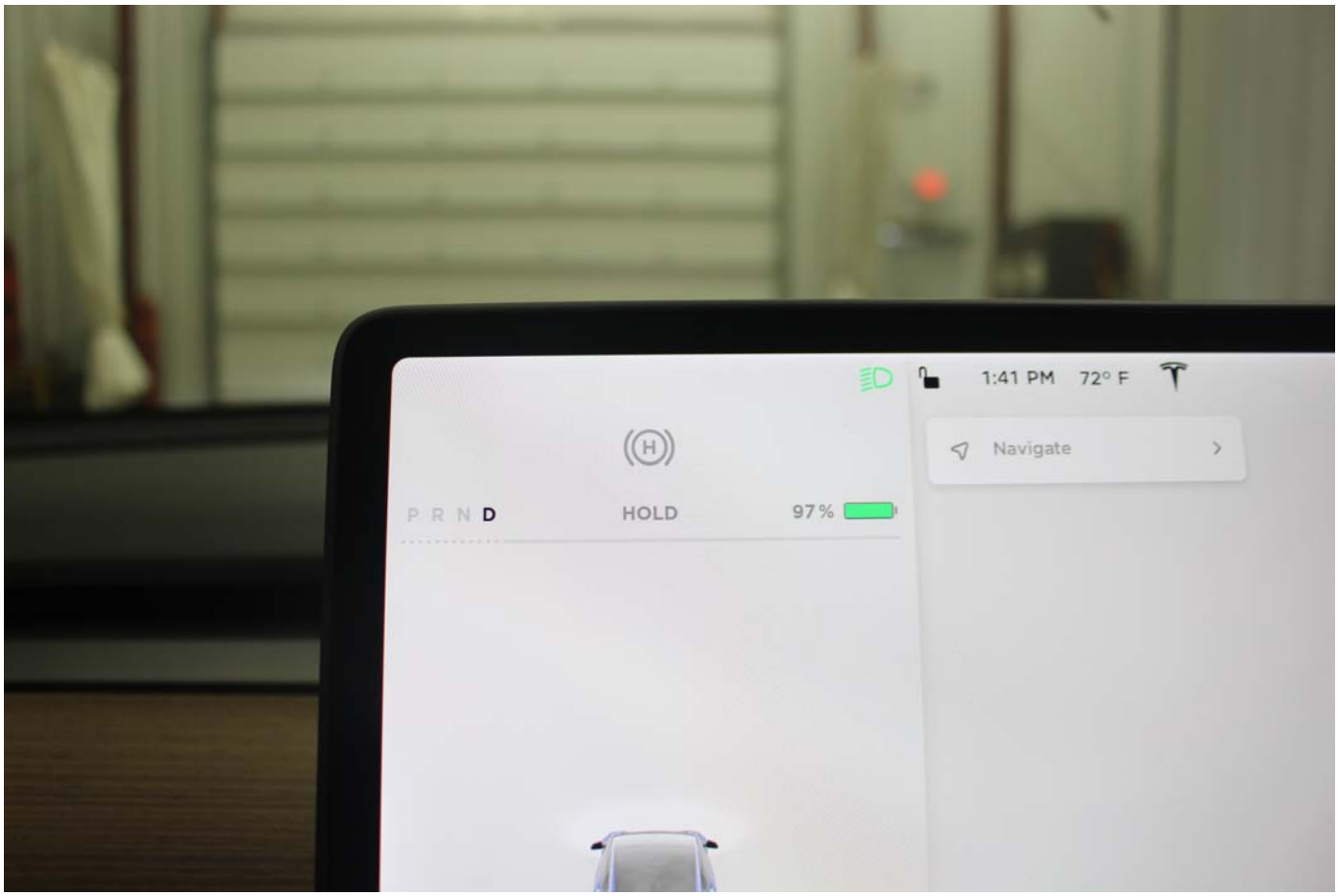


Photo No. 011 - Driver Leaving the Vehicle Indication

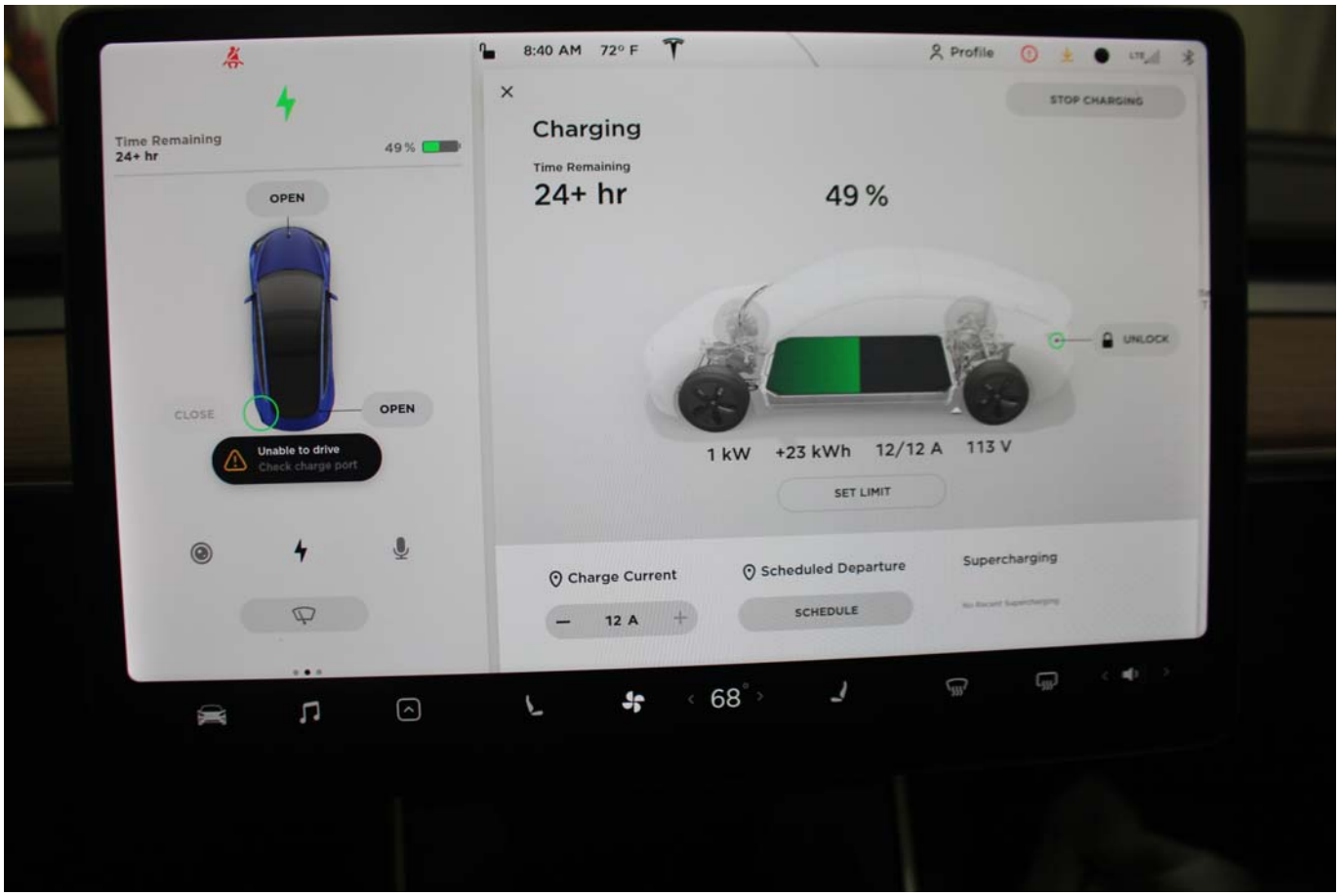


Photo No. 012 - Momentary Signal to Driver When Selecting Active Drive Mode While External Charging is Active

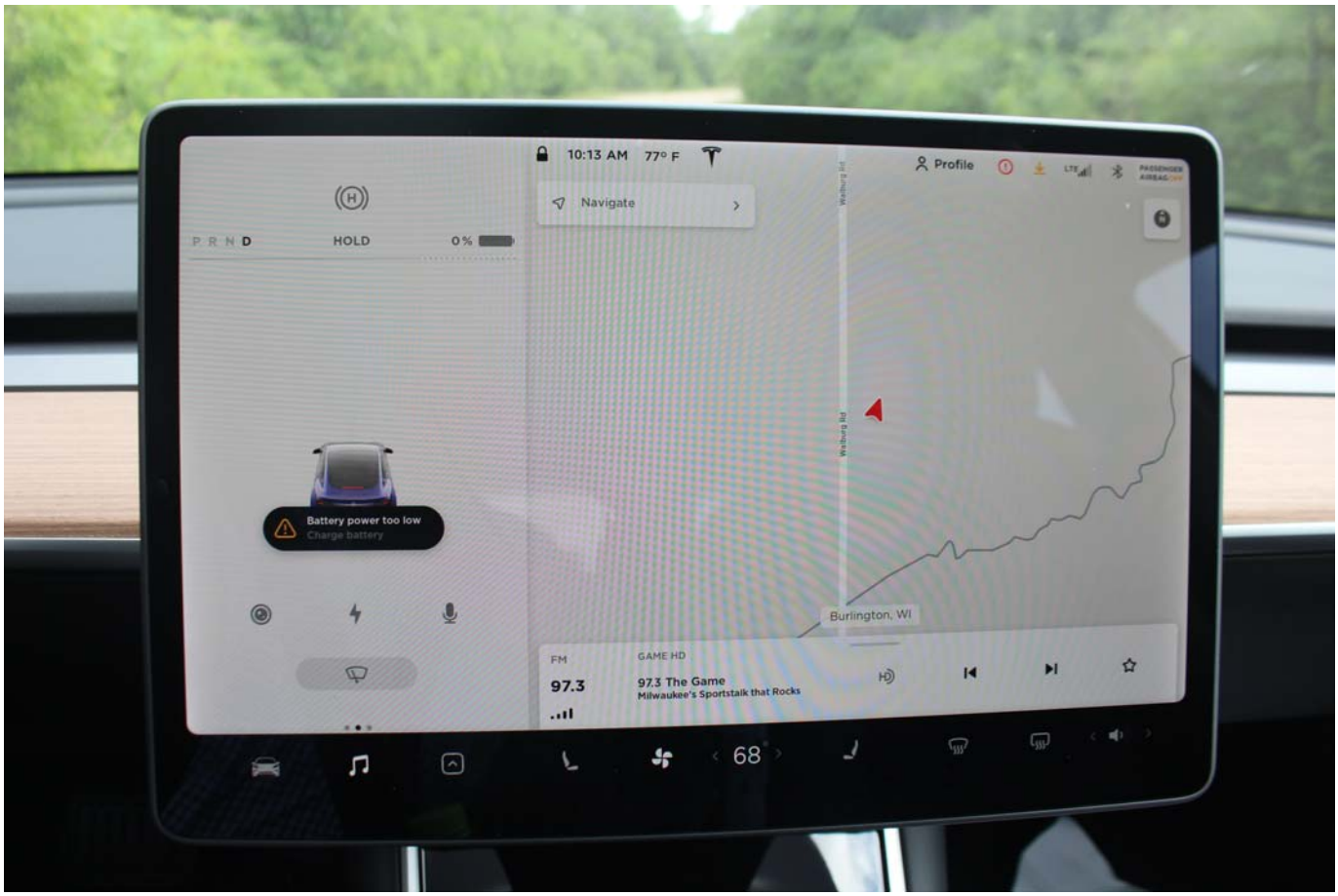


Photo No. 013 - Low Energy Warning to the Driver

PHOTOGRAPH NOT AVAILABLE

Photo No. 014 - External Short Circuit Breakout Harness

PHOTOGRAPH NOT AVAILABLE

Photo No. 015 - External Short Circuit Test Setup

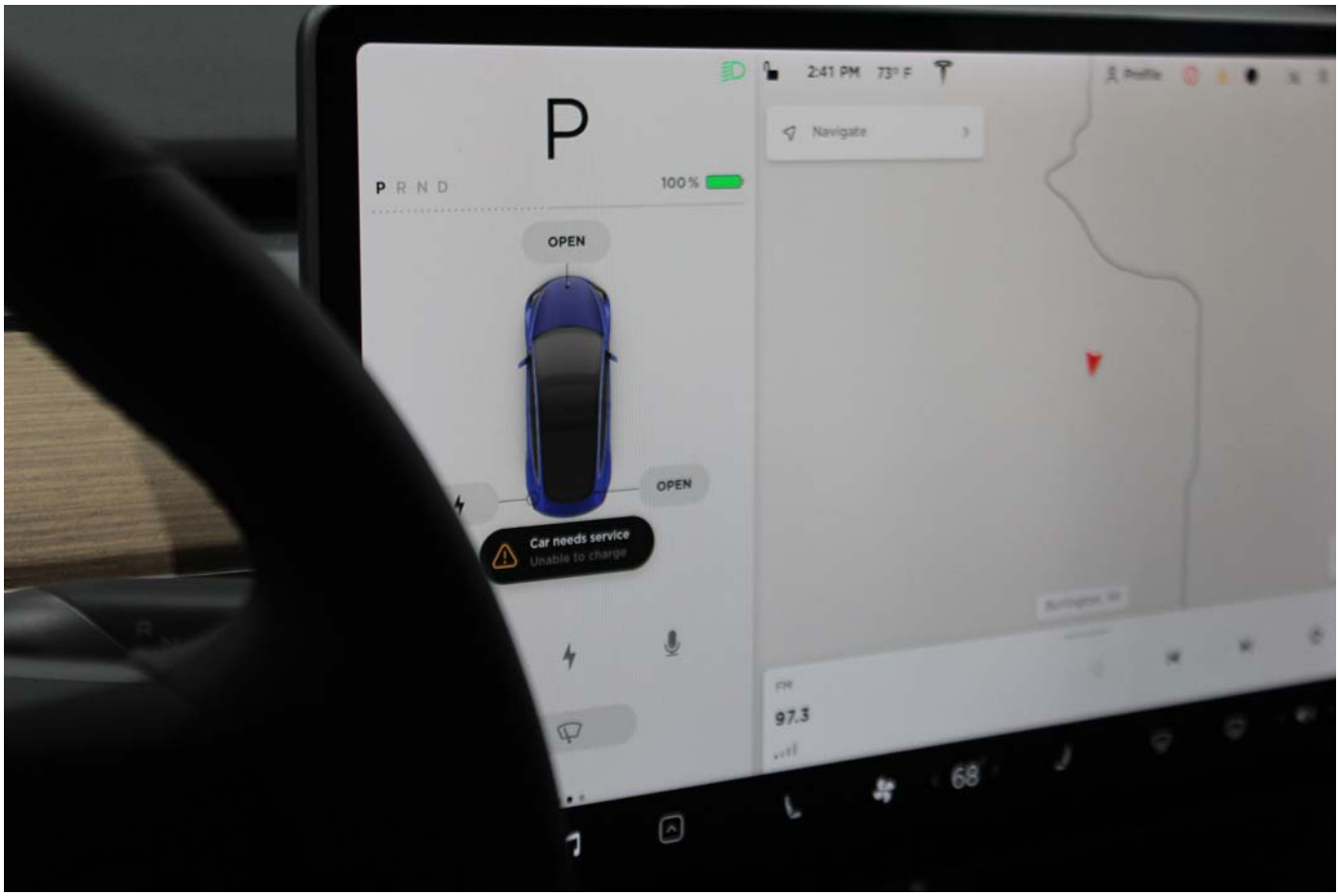


Photo No. 016 - External Short Circuit Vehicle - Post Test

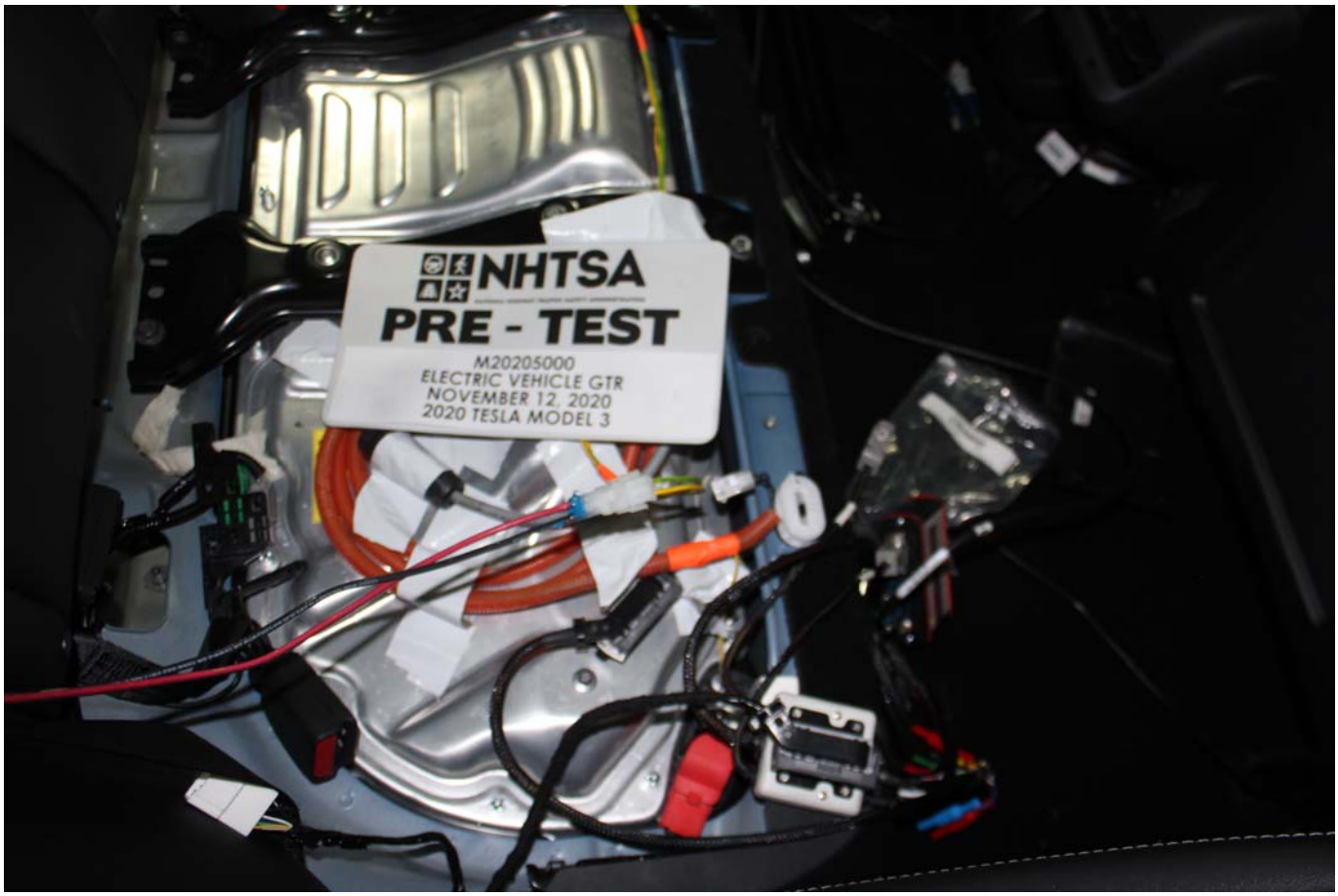


Photo No. 017 - Overcharge Breakout Harness

Photo No. 018 - Overcharge Test Setup

Photo No. 019 - Overcharge Vehicle - Post Test

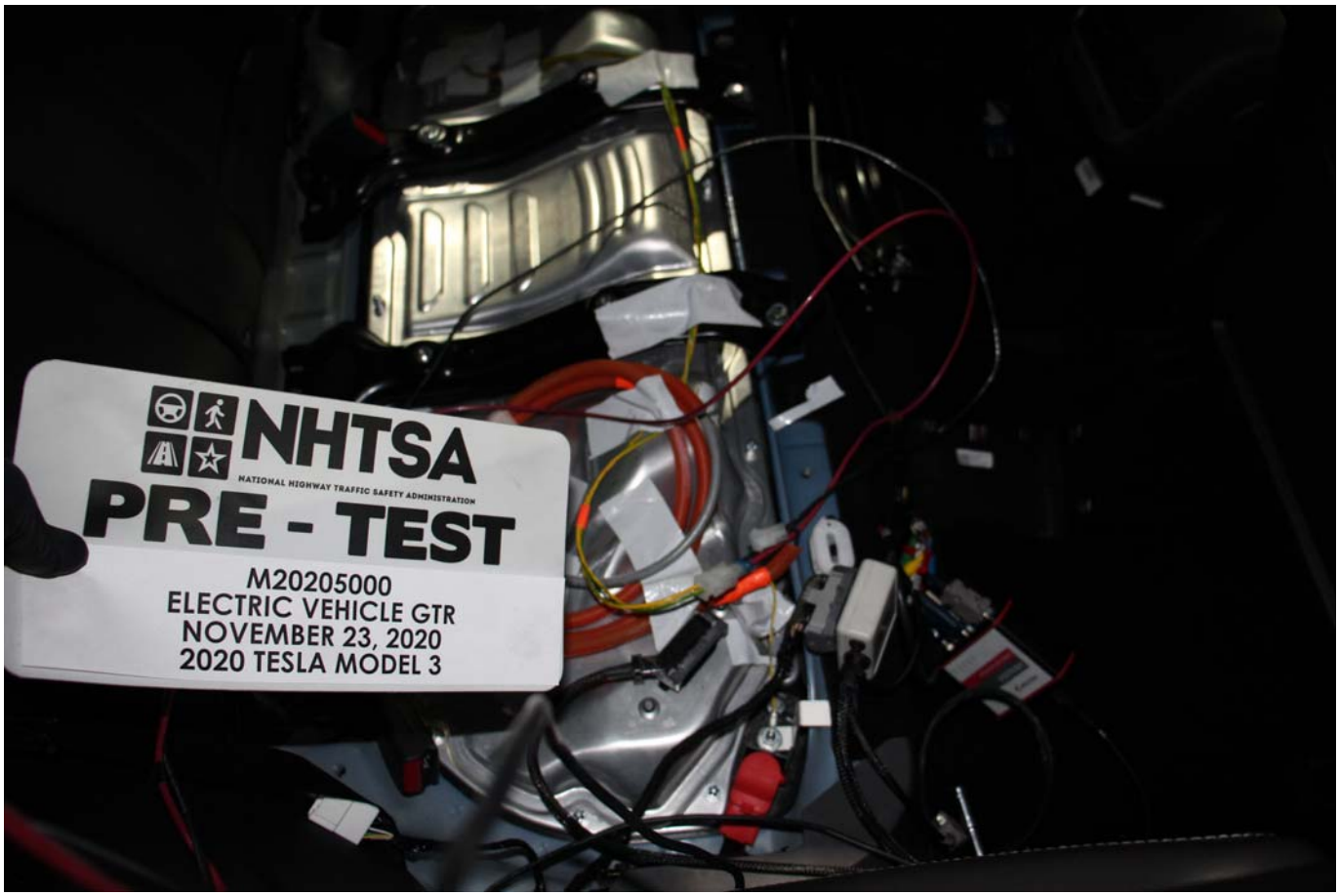


Photo No. 020 - Over-discharge Breakout Harness

Photo No. 021 - Over-discharge Test Setup

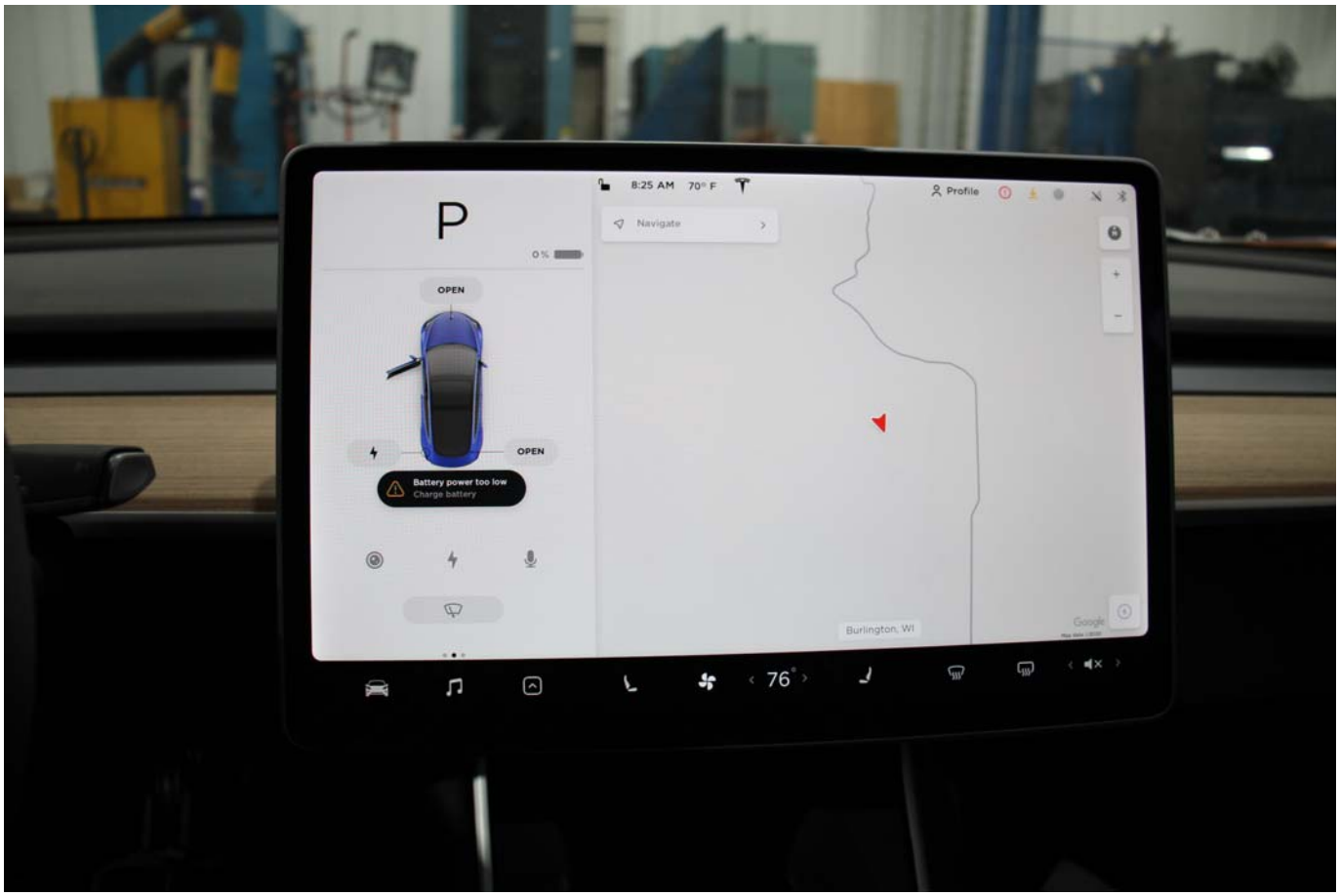


Photo No. 022 - Over-discharge Vehicle - Post Test

PHOTOGRAPH NOT APPLICABLE

Photo No. 023 - Over-temperature Breakout Harness

Photo No. 024 - Over-temperature Test Setup

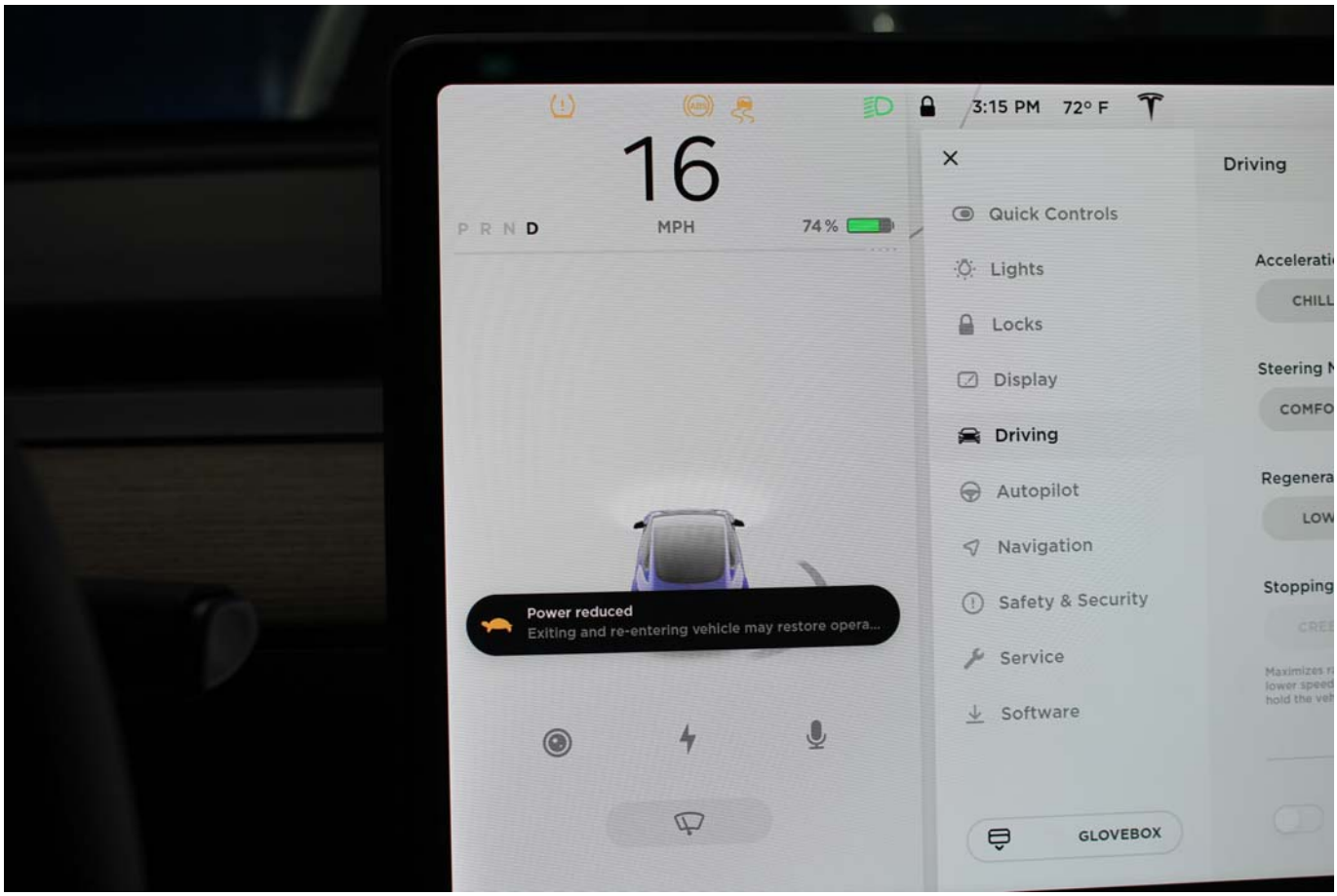


Photo No. 025 - Over-temperature Vehicle - Post Test

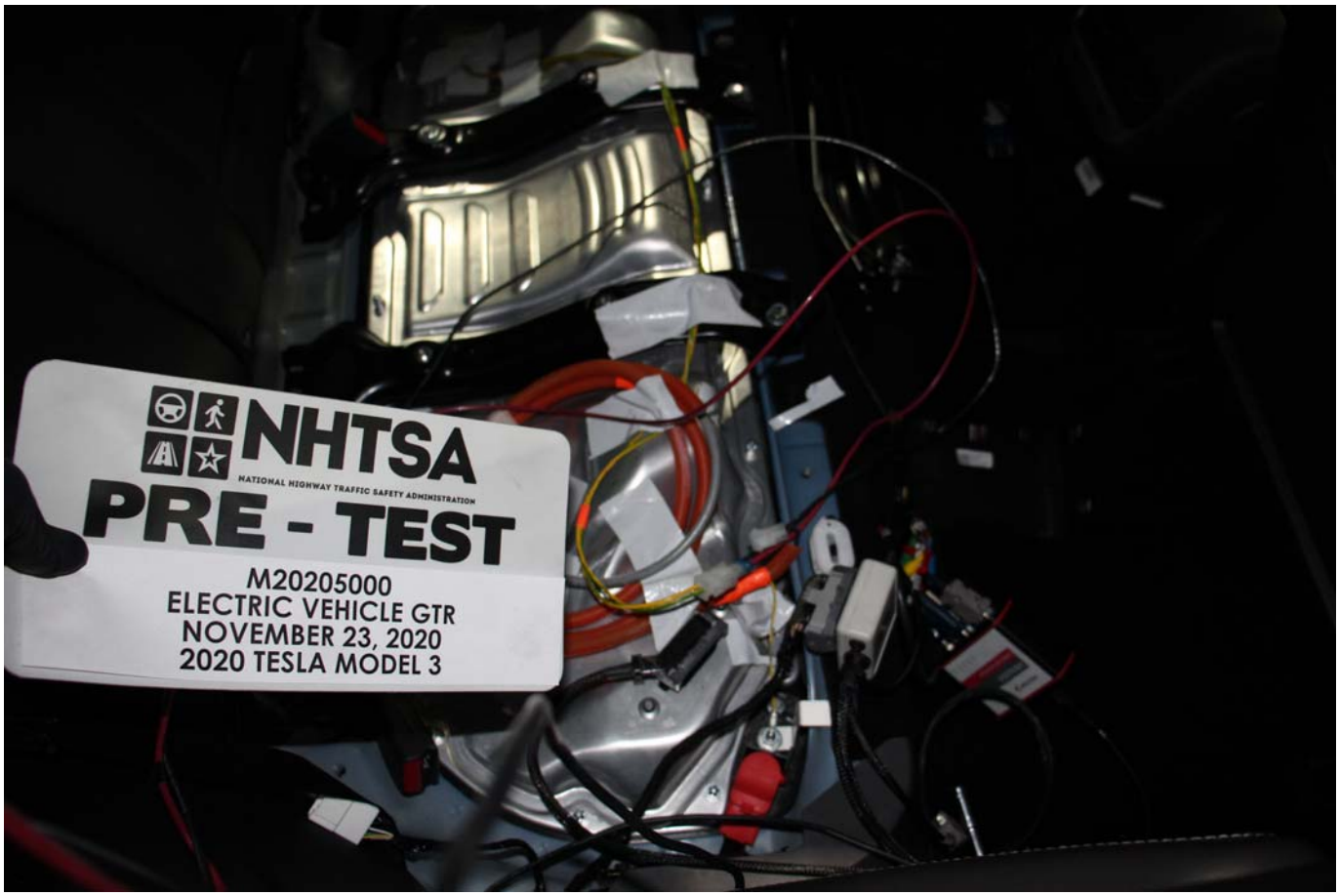


Photo No. 026 - Overcurrent Breakout Harness

Photo No. 027 - Overcurrent Test Setup

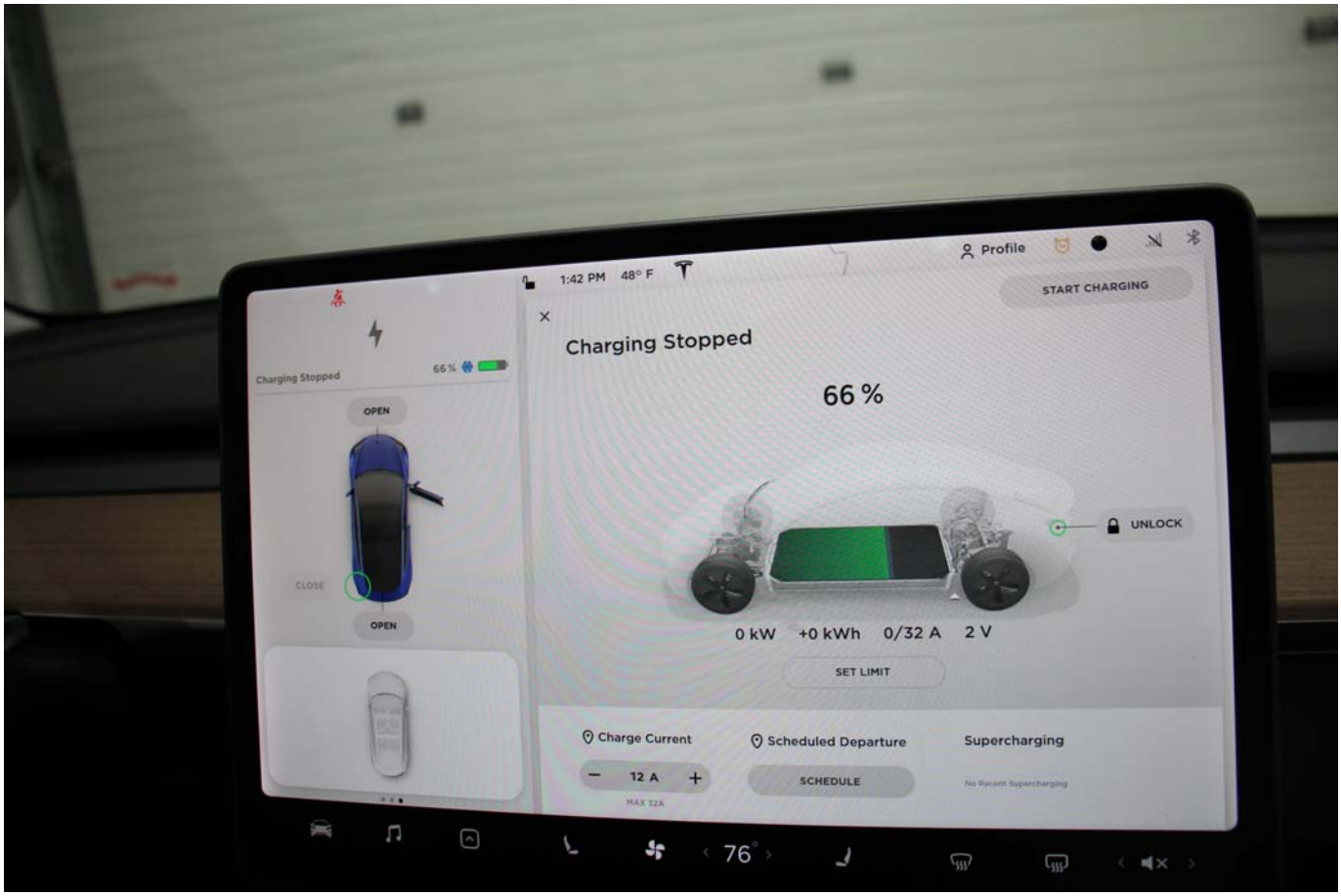
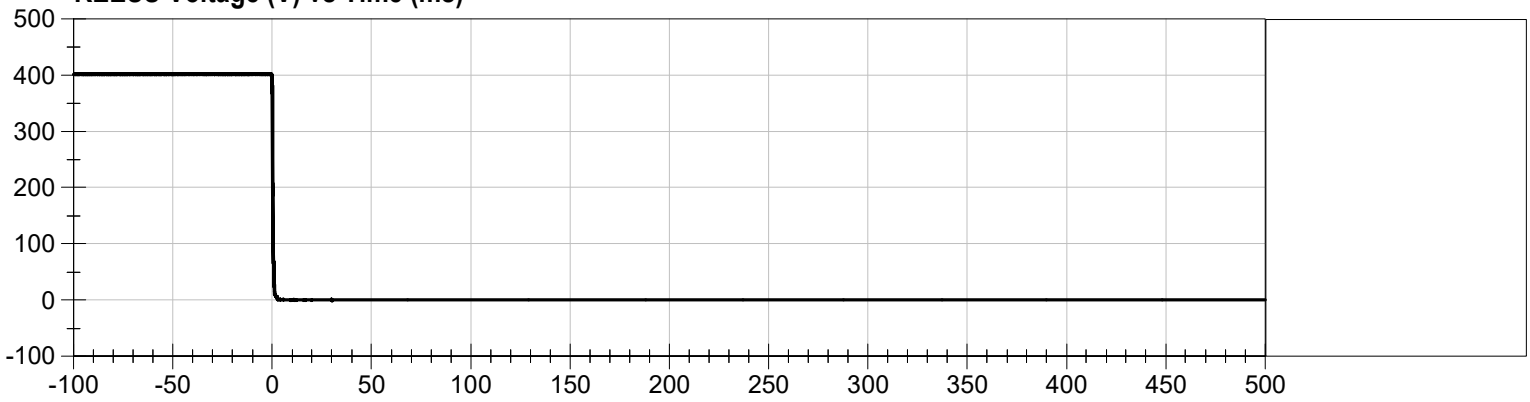


Photo No. 028 - Overcurrent Vehicle - Post Test

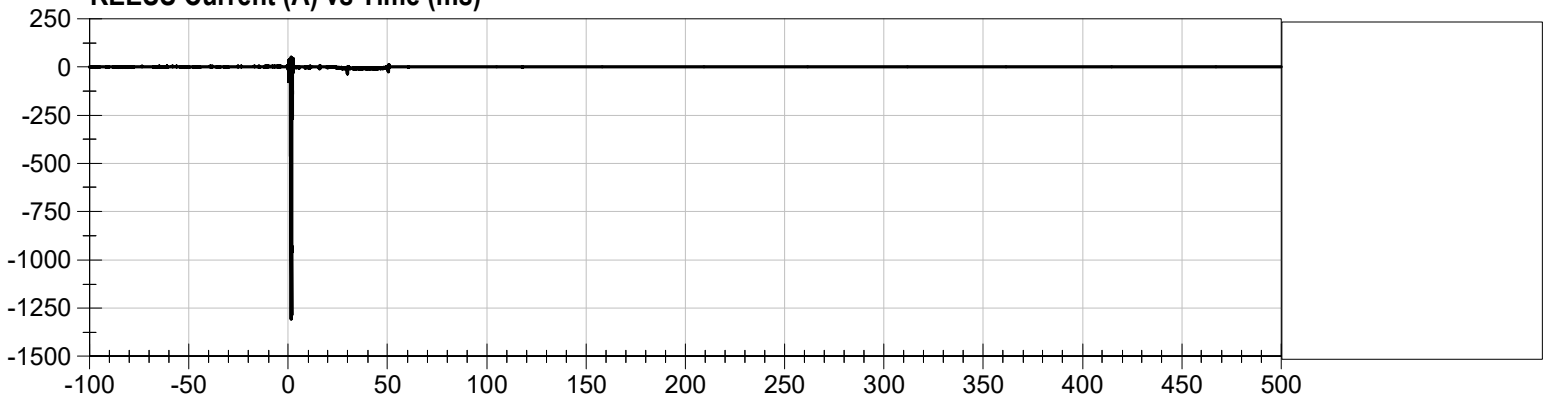
APPENDIX B
DATA TRACES

TABLE OF DATA PLOTS

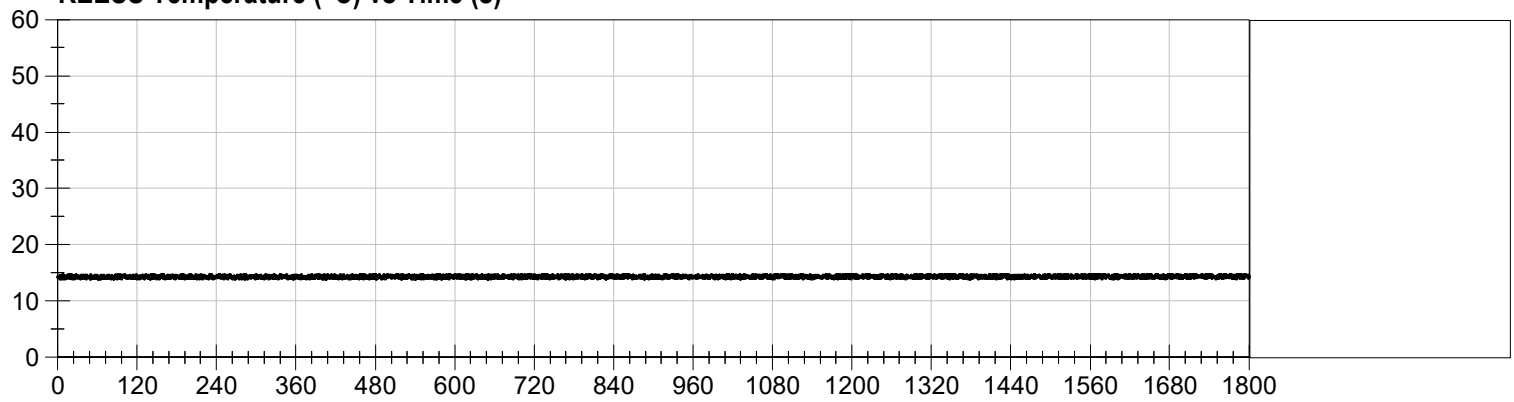
REESS Voltage (V) vs Time (ms)



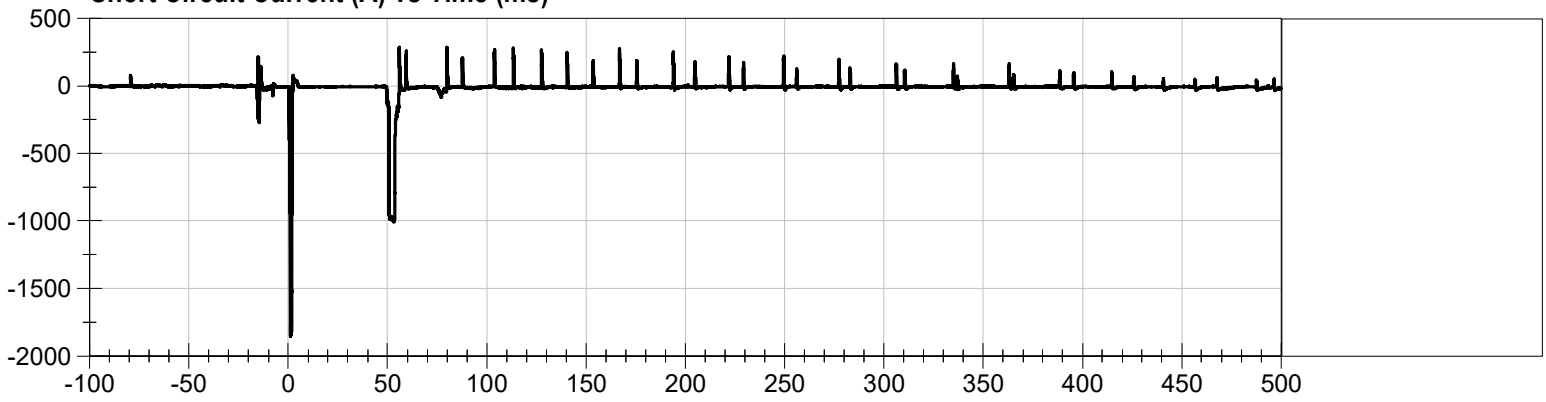
REESS Current (A) vs Time (ms)



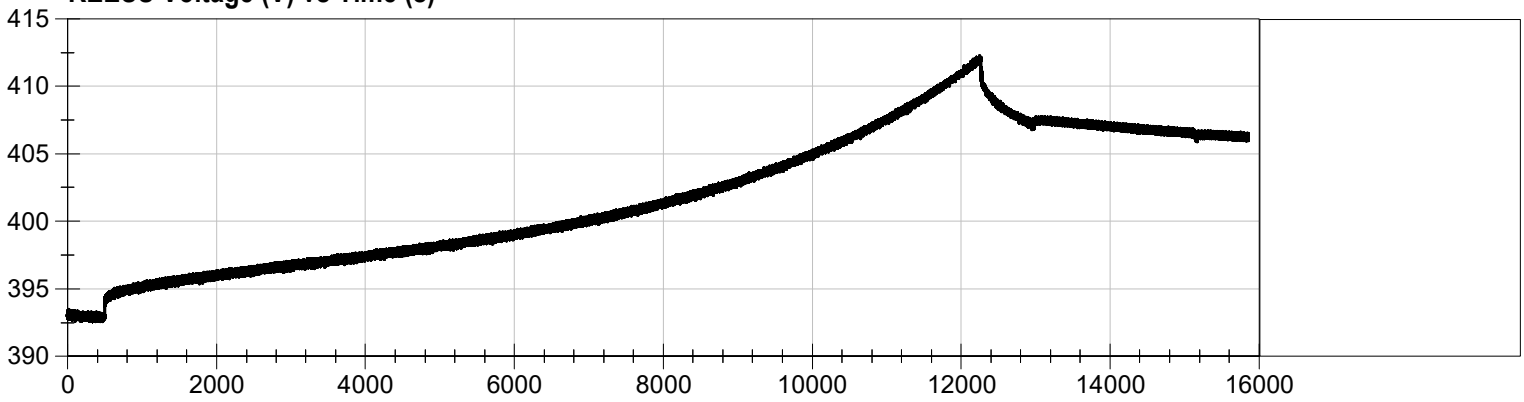
REESS Temperature (°C) vs Time (s)



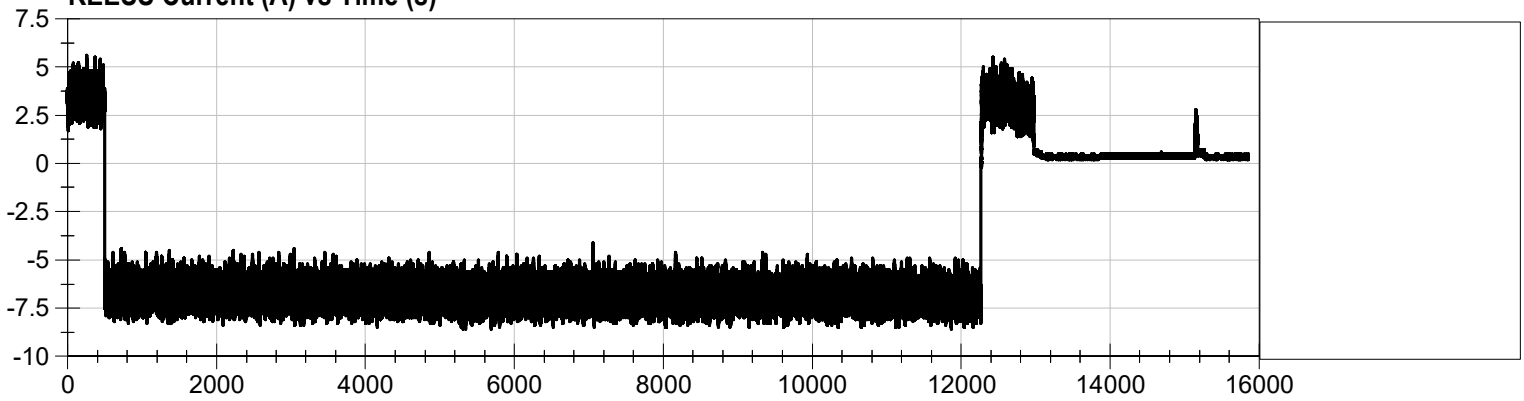
Short Circuit Current (A) vs Time (ms)



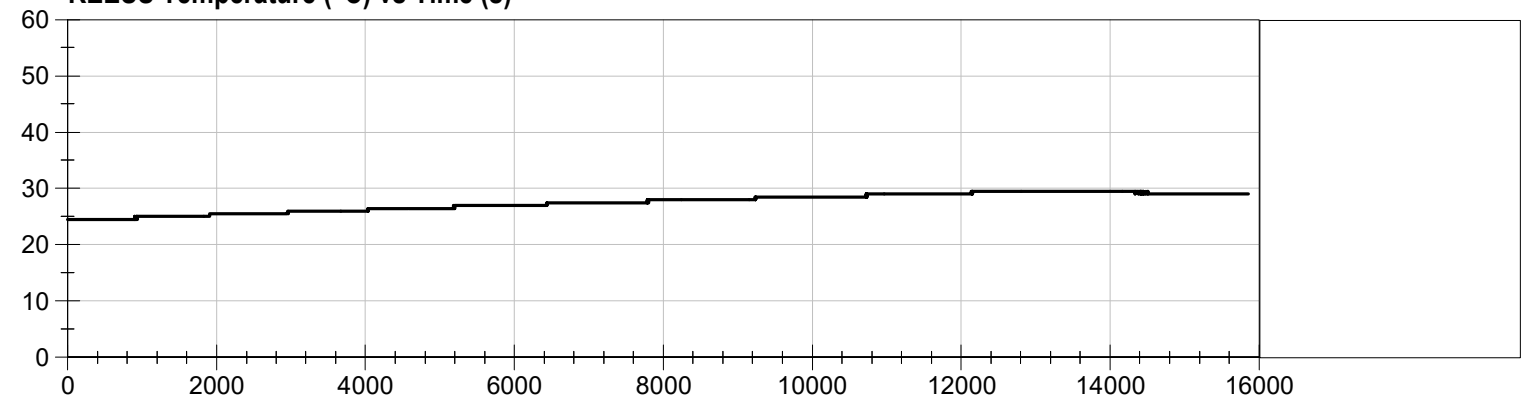
REESS Voltage (V) vs Time (s)



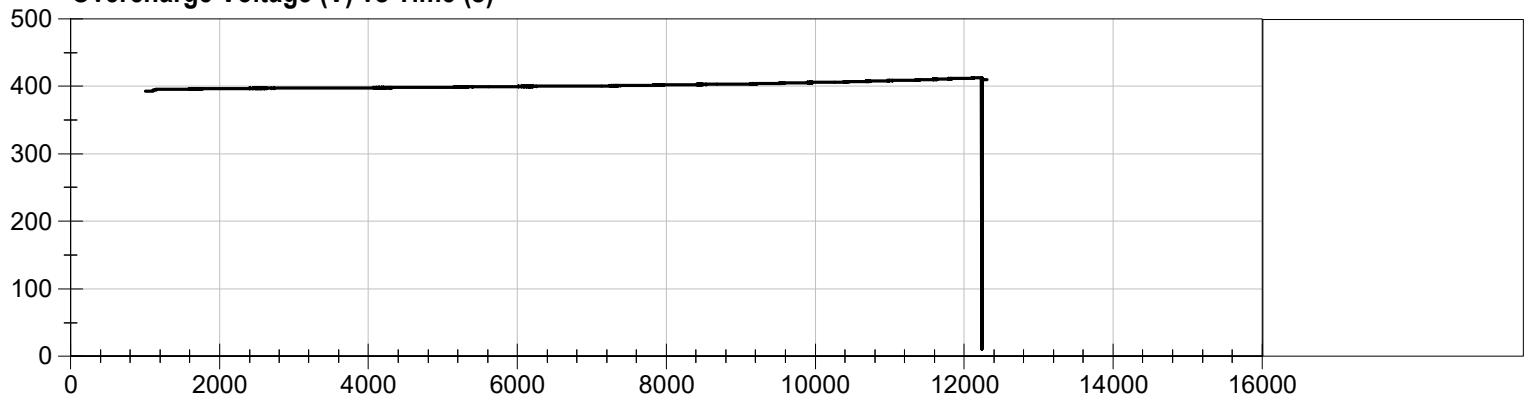
REESS Current (A) vs Time (s)



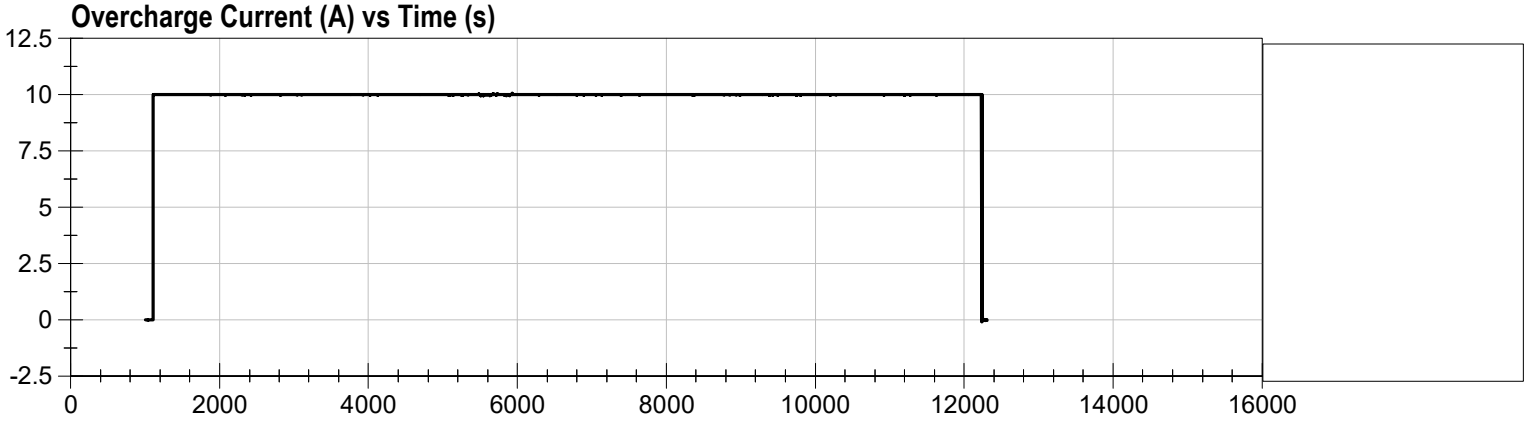
REESS Temperature (°C) vs Time (s)



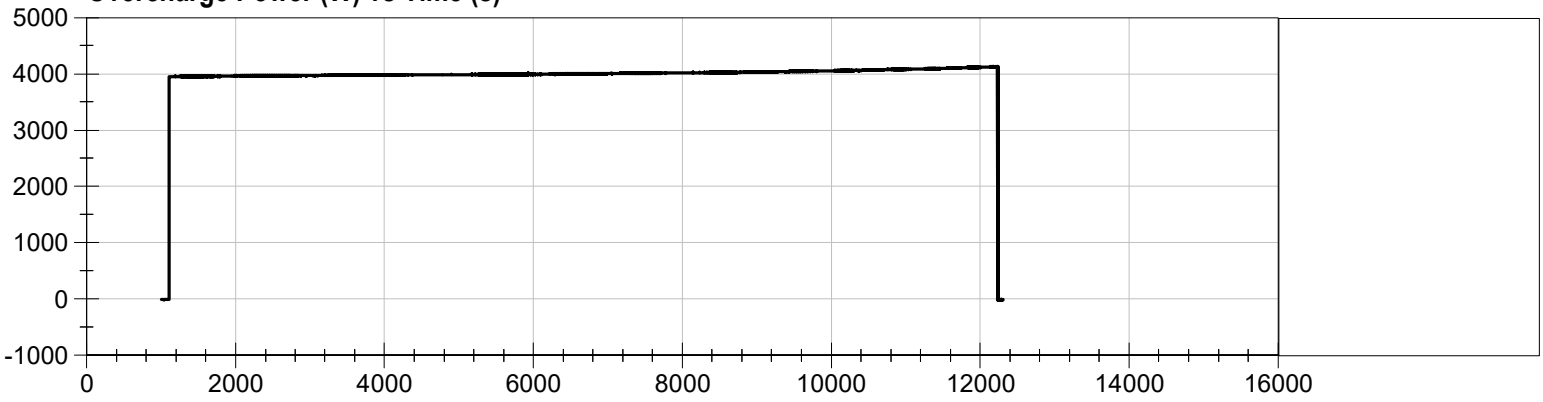
Overcharge Voltage (V) vs Time (s)



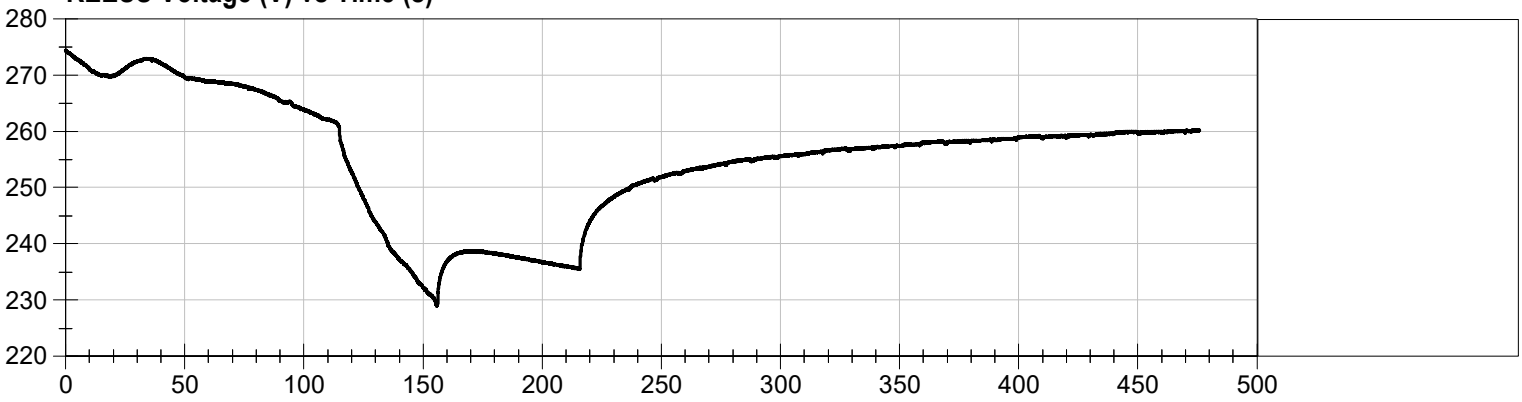
Overcharge Current (A) vs Time (s)



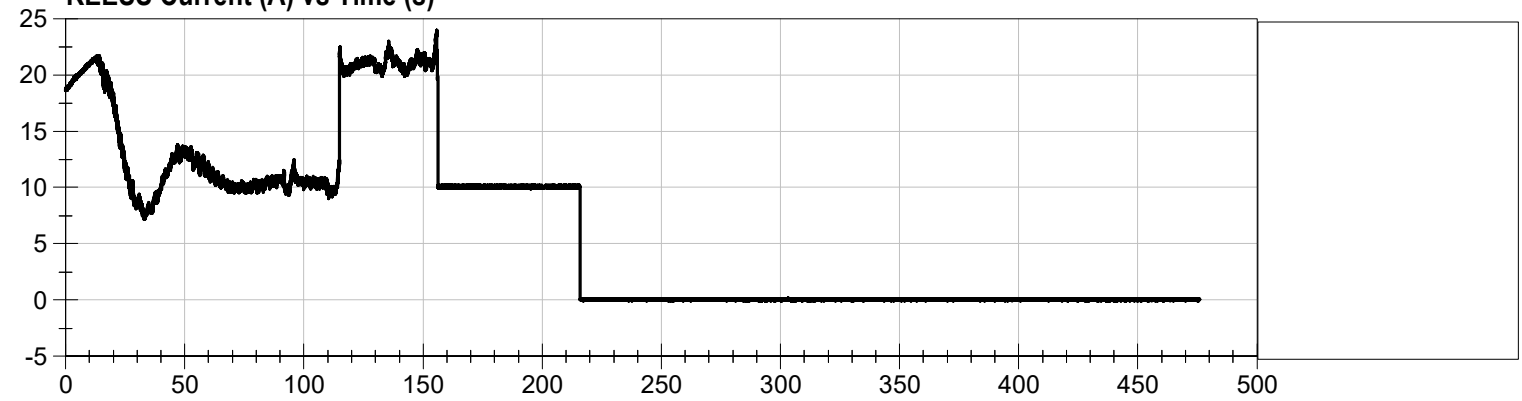
Overcharge Power (W) vs Time (s)



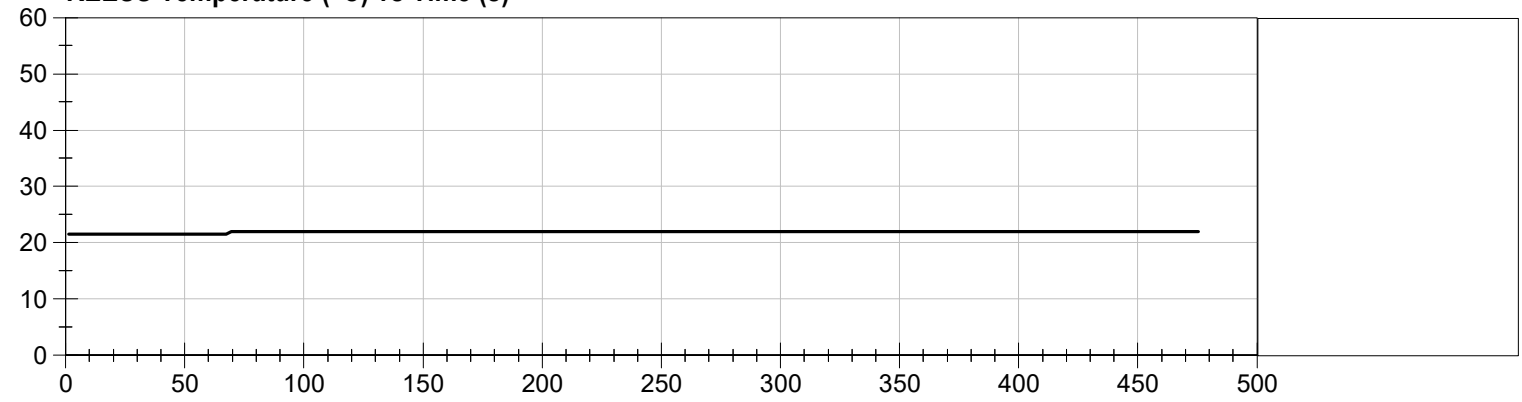
REESS Voltage (V) vs Time (s)



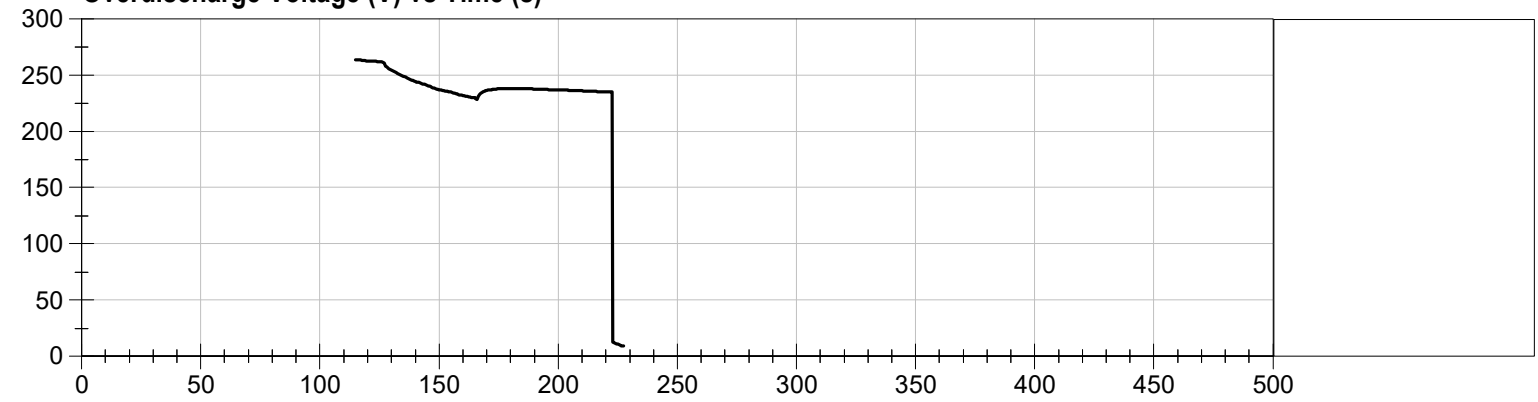
REESS Current (A) vs Time (s)



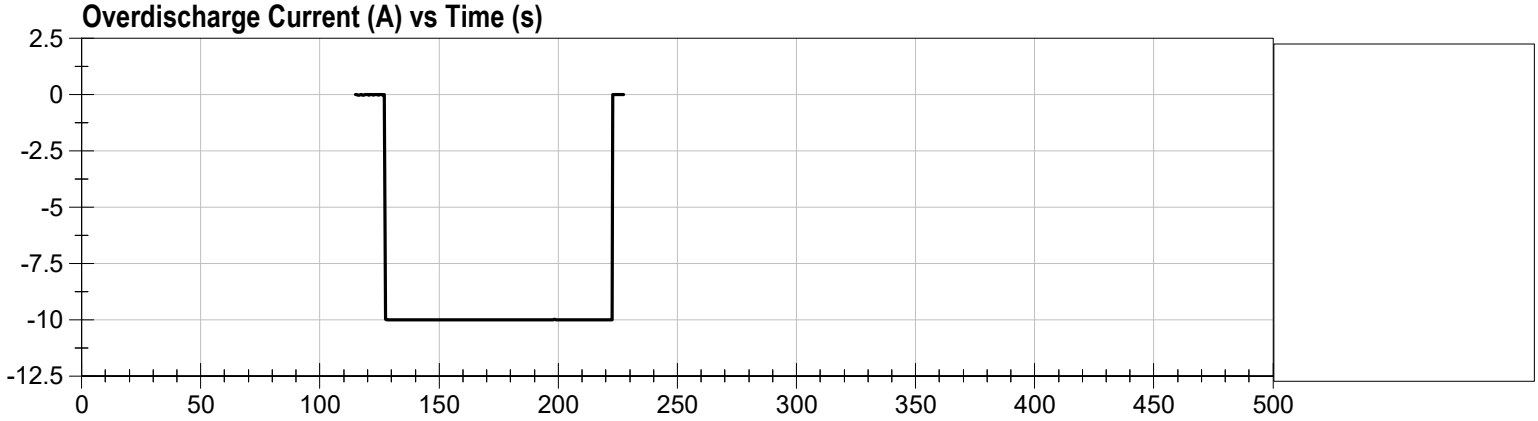
REESS Temperature (°C) vs Time (s)



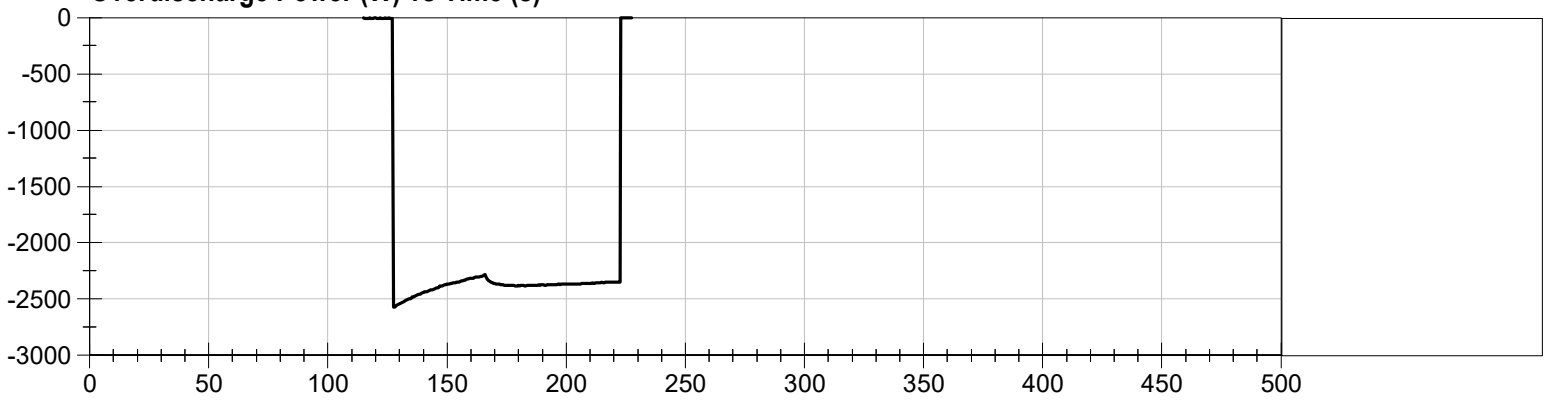
Overdischarge Voltage (V) vs Time (s)



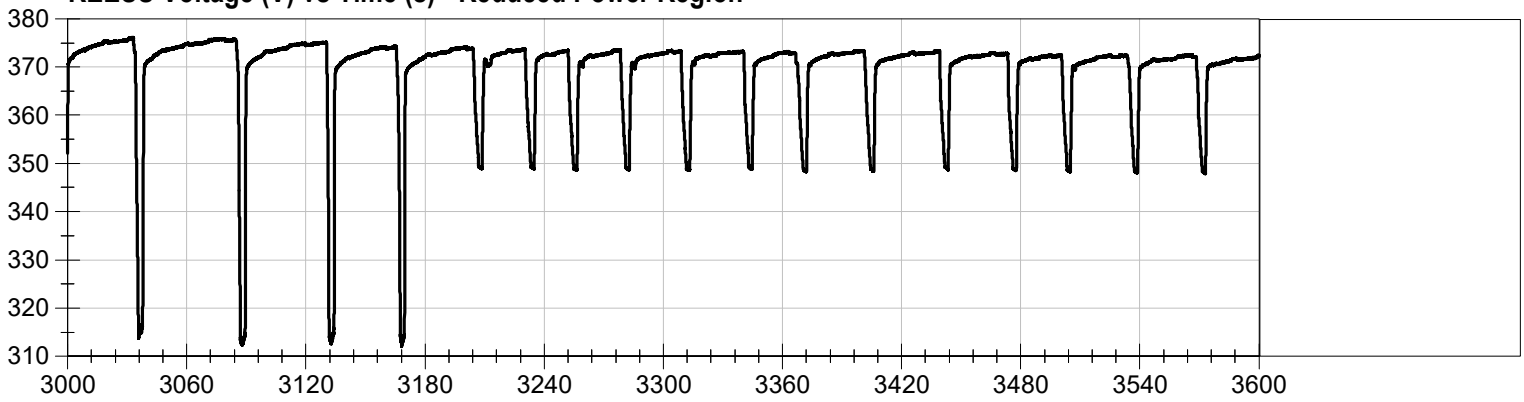
Overdischarge Current (A) vs Time (s)



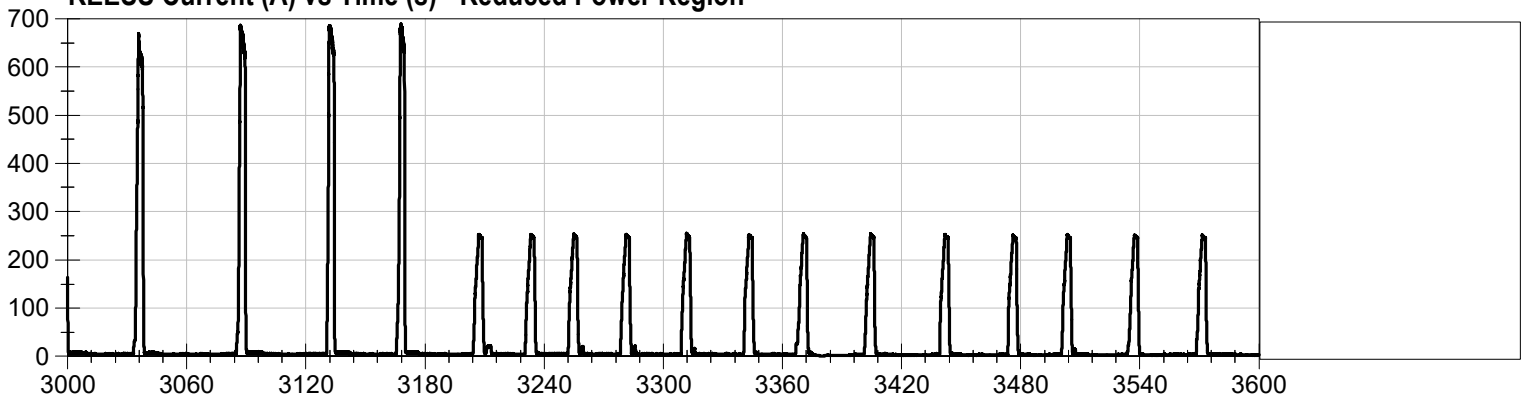
Overdischarge Power (W) vs Time (s)



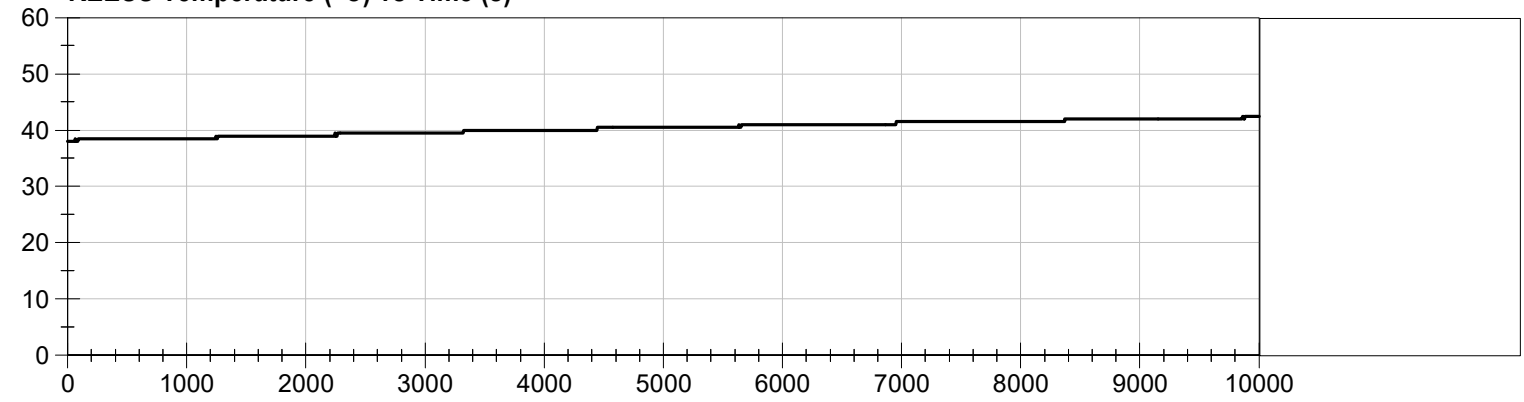
REESS Voltage (V) vs Time (s) - Reduced Power Region



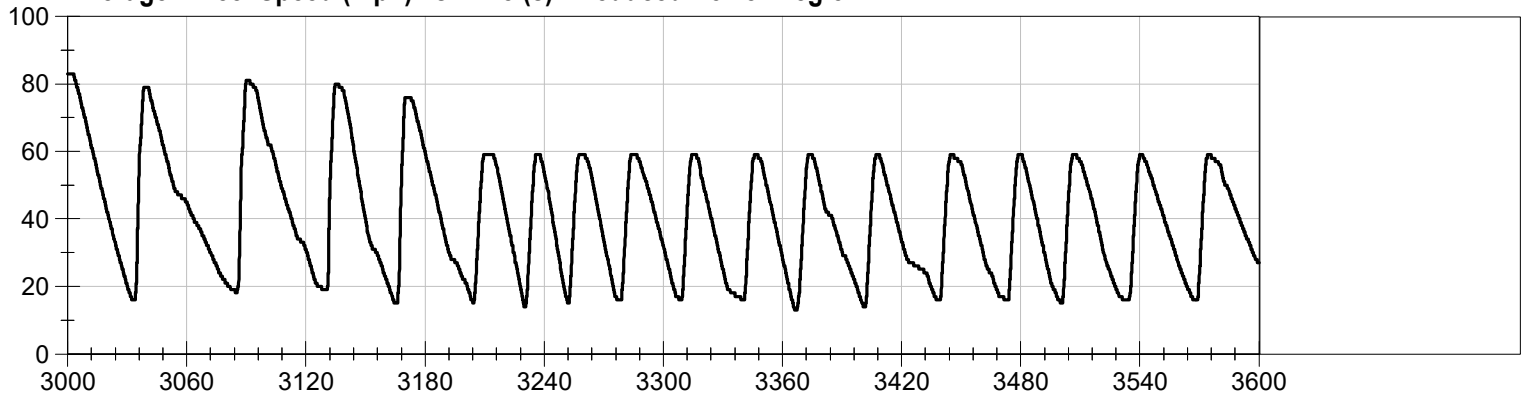
REESS Current (A) vs Time (s) - Reduced Power Region



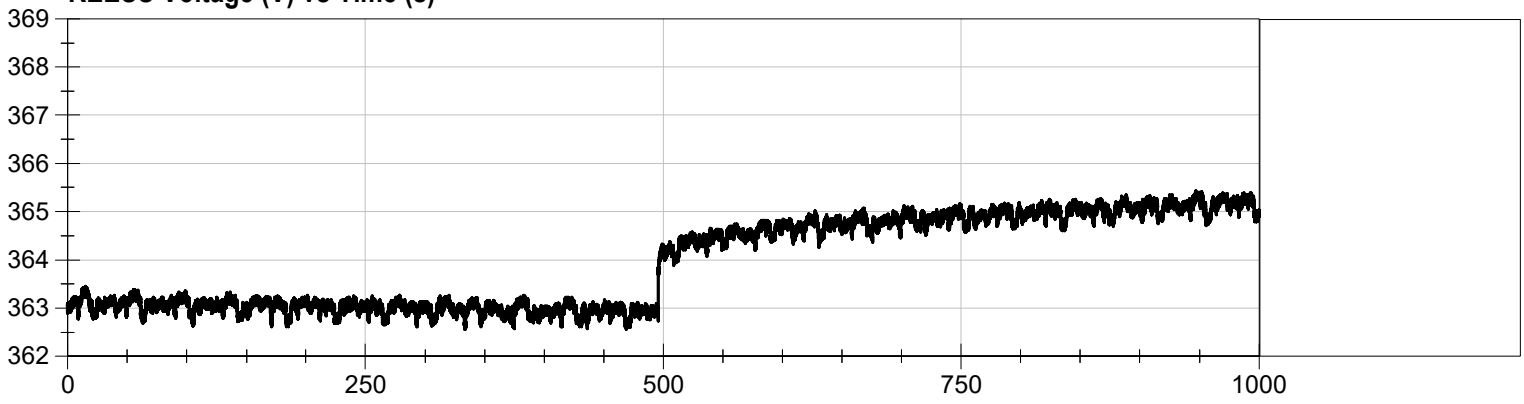
REESS Temperature (°C) vs Time (s)



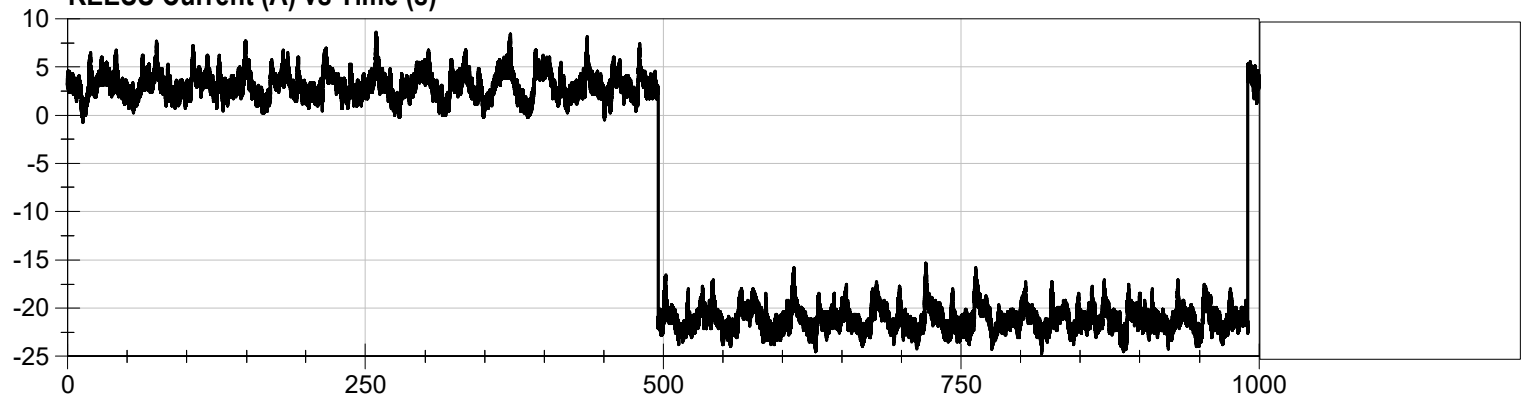
Average Wheel Speed (mph) vs Time (s) - Reduced Power Region



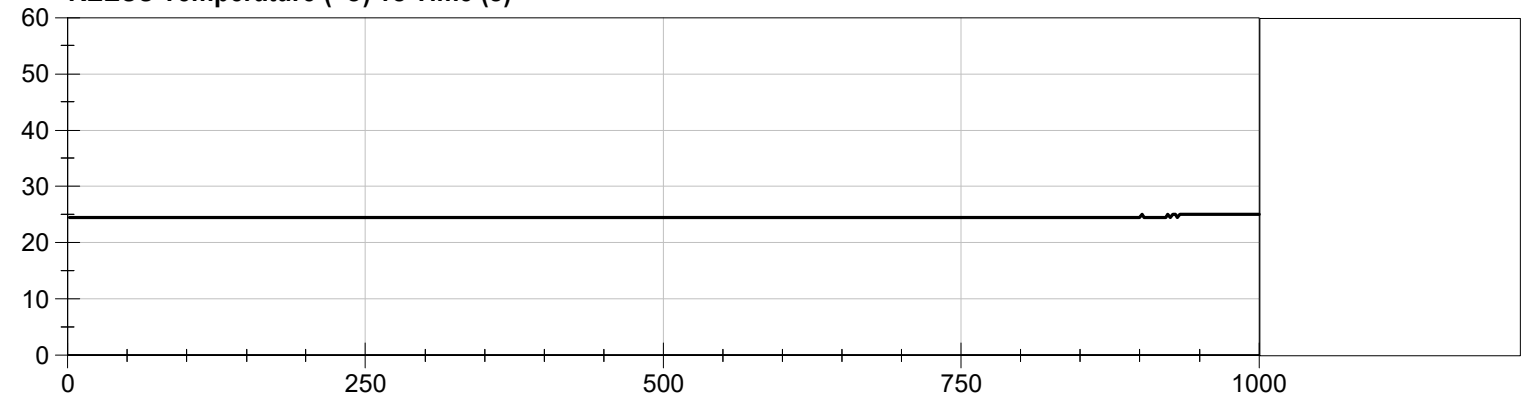
REESS Voltage (V) vs Time (s)

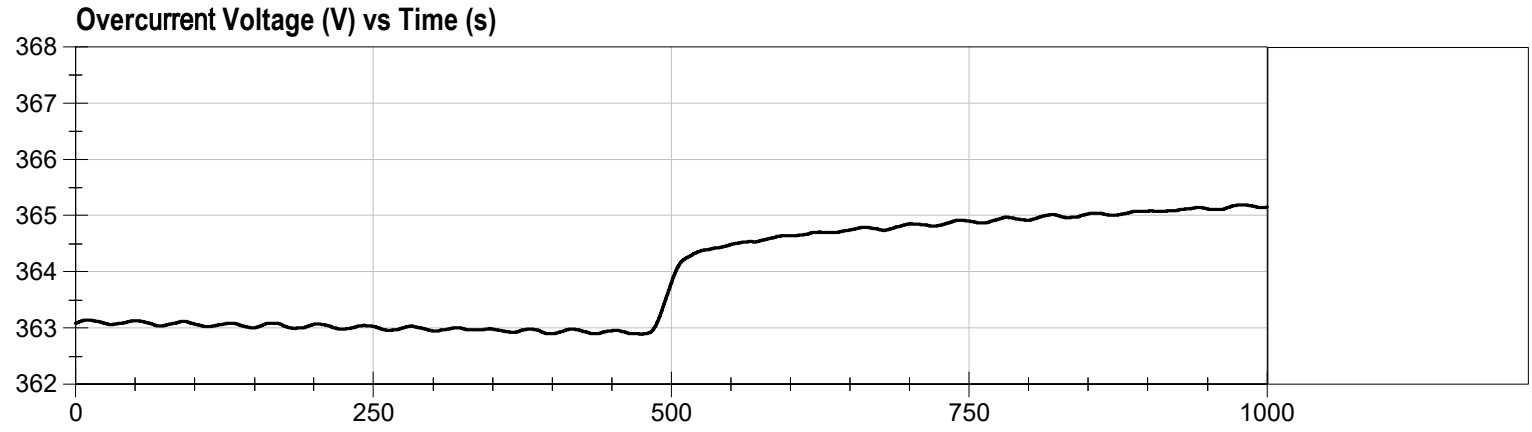


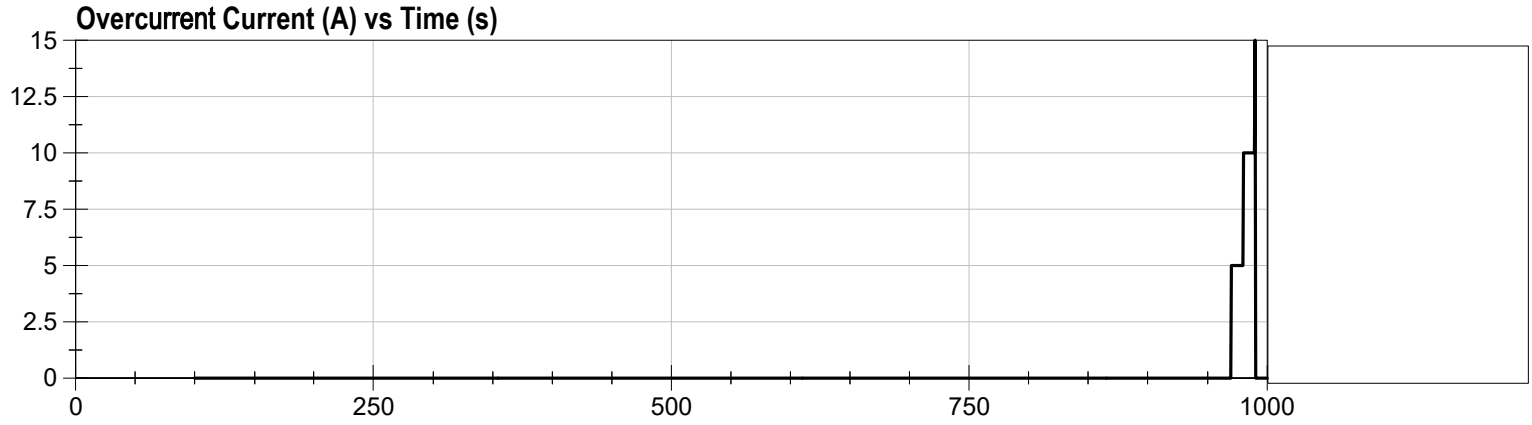
REESS Current (A) vs Time (s)

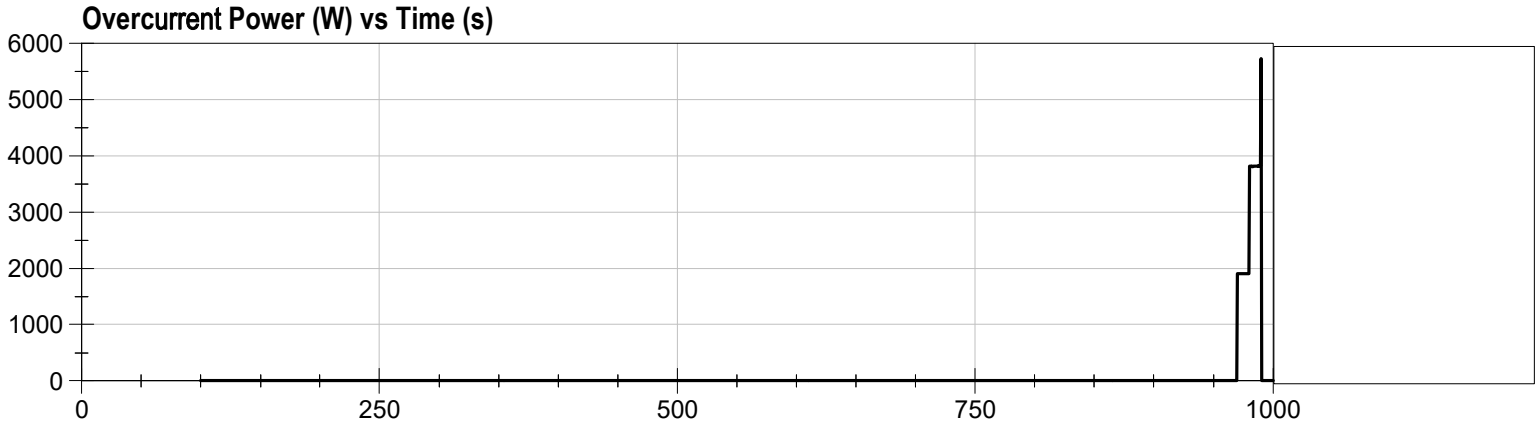


REESS Temperature (°C) vs Time (s)




Overcurrent Voltage (V) vs Time (s)
368
367
366
365
364
363
362
0
250
500
750
1000


Overcurrent Current (A) vs Time (s)
15
12.5
10
7.5
5
2.5
0
0
250
500
750
1000


Overcurrent Power (W) vs Time (s)
6000
5000
4000
3000
2000
1000
0
0
250
500
750
1000

APPENDIX C
TEST EQUIPMENT AND INSTRUMENTATION CALIBRATION DATA

TABLE 1 – TEST EQUIPMENT AND INSTRUMENTATION

Item	Serial Number	Manufacturer	Calibration Date
NHR 9300 Battery Test System	68281	NHR	08/23/2019
Digital Multimeter	22600211	Fluke	02/24/2020
Voltage Range Expander	VM114	MGA	09/02/2020

APPENDIX D
TEST PROCEDURE

U.S. DEPARTMENT OF TRANSPORTATION

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

LABORATORY PROCEDURE
for
GTR 20 ELECTRIC VEHICLE SAFETY
SECTION 5.1, 5.3, 5.4

May 2020

OFFICE OF RULEMAKING
OFFICE OF CRASHWORTHINESS STANDARDS
1200 NEW JERSEY AVE, SE
WASHINGTON, DC 20590

LABORATORY TEST PROCEDURE for GTR 20 ELECTRIC VEHICLE SAFETY
SECTION 5.1, 5.3, 5.4
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APPENDIX B TEST DELIVERABLES AND REPORT GUIDELINES

REVISION CONTROL LOG

TEST PROCEDURE		GTR 20 ELECTRIC VEHICLE SAFETY SECTION 5.1, 5.3, 5.4		DESCRIPTION
REV. No.	DATE	AMENDMENT	EFFECTIVE DATE	
00	04/30/2020			Initial draft laboratory test procedure for GTR 20 Electric Vehicle Safety Section 5.1, 5.3, 5.4
01	05/13/2020		TBD	Minor revisions/clarifications.

1. PURPOSE AND APPLICATION

The Office of Crashworthiness Standards (OCWS) provides Contractor laboratories with Laboratory Test Procedures as guidelines for obtaining vehicle test data. The purpose of the OCWS Laboratory Test Procedure is to present a uniform testing and data recording format, and to provide suggestions for the use of specific equipment and procedures. If any Contractor views any part of an OCWS Laboratory Test Procedure to be in conflict with a Federal Motor Vehicle Safety Standard (FMVSS) or observes deficiencies in a Laboratory Test Procedure, the Contractor is required to advise the Contracting Officer's Representative (COR) and resolve the discrepancy prior to the start of testing.

Every Contractor is required to submit a detailed internal test procedure to the COR before initiating the test program. The procedure must include a step-by-step description of the methodology to be used. The Contactor's test procedure shall contain a complete listing of the test equipment with make and model number. The list of test equipment shall include instrument accuracy and calibration dates. All equipment shall be calibrated in accordance with the manufacturer's instructions. There shall be no contradictions between the Laboratory Test Procedure and the Contractor's in-house test procedure. Written approval of the in-house test procedures shall be obtained from the COR before initiating the test program. The OCWS Laboratory Test Procedures are not intended to limit or restrain a Contractor from developing or utilizing any testing techniques or equipment which will assist in procuring the required data. These Laboratory Test Procedures do not constitute an endorsement or recommendation for use of any product or method. However, the application of any such testing technique or equipment is subject to prior approval of the COR.

2. GENERAL REQUIREMENTS

2.1 PROTECTION AGAINST ELECTRICAL SHOCK (5.1.1.)

The vehicle shall meet the requirements of Section 5.1.1.1. and Section 5.1.1.2. of GTR No. 20.

A. PROTECTION AGAINST DIRECT CONTACT (5.1.1.1.)

Protection degree IPXXD shall be provided for high voltage live parts inside the passenger compartment or luggage compartment.

Protection degree IPXXB shall be provided for high voltage live parts in areas other than the passenger compartment or luggage compartment.

For a high voltage service disconnect which can be opened, disassembled or removed without tools, protection degree IPXXB shall be satisfied when it is opened, disassembled or removed without tools.

The symbol shown in Figure 1 shall be present on or near the REESS having high voltage capability. The symbol background shall be yellow, the bordering and the arrow shall be black.

Cables for high voltage buses which are not located within enclosures shall have an orange outer covering.

Figure 1- Marking of High Voltage Equipment

B. PROTECTION AGAINST INDIRECT CONTACT (5.1.1.2.)

The resistance between all exposed conductive parts and the electrical chassis shall be lower than 0.1 Ω when there is current flow of at least 0.2 A.

The resistance between any two simultaneously reachable exposed conductive parts of the electrical protection barriers that are less than 2.5 meters from each other shall not exceed 0.2 Ω.

In vehicles that are equipped to be charged by an external power source, a device to enable the conductive connection of the electrical chassis to the earth ground for the external charger shall be provided. The device shall enable connection to the earth ground prior to external voltage being applied and retain the connection until after external voltage is removed from the vehicle.

If the electrical power train consists of separate isolated DC- and AC-buses, the isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 100 Ω/V of the working voltage for DC buses, and a minimum value of 500 Ω/V of the working voltage for AC buses.

If the electrical power train consists of combined DC- and AC-buses that are conductively connected the isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 500 Ω/V of the working voltage.

In fuel cell vehicles, DC high voltage buses shall have an on-board isolation resistance monitoring system together with a warning to the driver if the isolation resistance drops below the minimum required value of 100 Ω/V.

In vehicles that are equipped to be charged by an external power source, the isolation resistance between the vehicle inlet high voltage contacts and electrical chassis shall have a minimum value of 100 Ω/V for DC sources and 500 Ohm/V for AC sources.

2.2 FUNCTIONAL SAFETY (5.1.2.)

The vehicle shall meet the requirements of Section 5.1.2 of GTR No. 20.

A. MOMENTARY INDICATION WHEN PLACED IN ACTIVE DRIVING MODE (5.1.2.1.)

At least a momentary indication shall be given to the driver each time when the vehicle is first placed in "active driving possible mode" after manual activation of the propulsion system.

B. DRIVER TO BE INFORMED WHEN LEAVING THE VEHICLE (5.1.2.2.)

When leaving the vehicle, the driver shall be informed by a signal if the vehicle is still in the active driving possible mode.

C. STATE OF DRIVE DIRECTION INDENTIFICATION (5.1.2.3.)

The state of the drive direction control unit shall be identified to the driver.

D. VEHICLE MOVEMENT WHILE EXTERNALLY CHARGING (5.1.2.4.)

Vehicle movement while physically connected to an external charger through the vehicle inlet shall be impossible.

2.3 FUNCTIONALITY OF REESS IN A VEHICLE (5.3.)

The vehicle shall meet the requirements of Section 5.3.2, 5.3.3, and 5.3.4 of GTR No. 20.

A. WARNING IN THE EVENT OF OPERATIONAL FAILURE OF VEHICLE CONTROLS THAT MANAGE REESS SAFE OPERATON (5.3.2.)

The vehicle shall provide a warning to the driver when the vehicle is in active driving possible mode in the event of operational failure of the vehicle controls that manage the safe operation of the REESS.

B. WARNING IN THE CASE OF THERMAL EVENT WITHIN THE REESS (5.3.3.)

The vehicle shall provide a warning to the driver in the case of a thermal event in the REESS (as specified by the manufacturer) when the vehicle is in active driving possible mode. Optical warnings shall be visible to the driver under both daylight and night-time driving conditions.

The warning tell-tale shall be activated as a check of lamp function either when the propulsion system is turned to the "On" position, or in the check position between "Start" and "On". This requirement does not apply to the optical signal or text shown in a common space.

C. WARNING IN THE EVENT OF LOW ENGERY CONTENT OF REESS (5.3.4.)

For BEVs (vehicles in which propulsion system are powered only by a REESS), a warning to the driver in the event of low REESS state of charge shall be provided.

2.4 REESS SAFETY – IN USE (5.4.)

The vehicle shall meet the requirements of Section 5.4.5, Section 5.4.6, Section 5.4.7, Section 5.4.8, and Section 5.4.9 of GTR No. 20.

A. EXTERNAL SHORT CIRCUIT (5.4.5.)

While tested in accordance with Section 6.2.5 of GTR No. 20 the vehicle shall display no evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

For high voltage REESS, the isolation measured after the test shall not be less than 100 Ω/V.

B. OVERCHARGE PROTECTION (5.4.6)

While tested in accordance with Section 6.2.6 of GTR No. 20 the vehicle shall display no evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

For high voltage REESS, the isolation measured after the test shall not be less than 100 Ω/V.

C. OVER-DISCHARGE PROTECTION (5.4.7.)

While tested in accordance with Section 6.2.7 of GTR No. 20 the vehicle shall display no evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

For high voltage REESS, the isolation measured after the test shall not be less than 100 Ω/V.

D. OVER-TEMPERATURE PROTECTION (5.4.8.)

While tested in accordance with Section 6.2.8 of GTR No. 20 the vehicle shall display no evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

For high voltage REESS, the isolation measured after the test shall not be less than 100 Ω/V.

E. OVERCURRENT PROTECTION (5.4.9.)

While tested in accordance with Section 6.2.9 of GTR No. 20 the vehicle shall display no evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

For high voltage REESS, the isolation measured after the test shall not be less than 100 Ω/V.

2.5 METRIC SYSTEM OF MEASUREMENT

Section 5164 of the Omnibus Trade and Competitiveness Act (Pub. L. 100-418) establishes that the metric system of measurement is the preferred system of weights and measures for trade and commerce in the United States. Executive order 12770 directs Federal agencies to comply with the Act by converting regulatory standards to the metric system after September 30, 1992. In a final rule published on March 15, 1990 (60 FR 13639), NHTSA completed the first phase of metrication, converting English measurements in several regulatory standards to the metric system. Since then, metrication has been applied to other regulatory standards (63 FR 28912) and will be applied to data collection related to the procedure.

Accordingly, this OCWS laboratory test procedure complies with governmental directives in using the metric system. For any testing equipment that is not available for direct measurement in metric units, the test laboratory shall calculate the exact metric equivalent by mean of a conversion factor carried out to at least five significant digits before rounding consistent with the specified metric requirement.

All final test reports are required to include metric measurements.

NOTE: The methodology for rounding measurement in the test reports shall be made in accordance with ASTM E29-06b, "Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications."

3. SECURITY

The Contractor shall provide appropriate security measures to protect NCAP test vehicles, dummies, load cell barriers, and any Government-furnished property (GFP) during the entire crash test program and shall be responsible for all equipment removed from test vehicles before and after the crash test. Any security problems which arise shall be reported by telephone to the Industrial Property Manager (IPM), Office of Acquisition Management, within two (2) working days after the incident. A letter containing specific details of the security problem shall be sent to the IPM (with copy to the COR) within 48 hours. Vehicle equipment thefts or acts of vandalism must be reported to NHTSA authorities immediately. Under no circumstances shall any vehicle components be removed during a visitor inspection unless authorized by OCWS engineers. All data developed from the crash test program shall be protected.

NO INDIVIDUALS OTHER THAN THE CONTRACTOR'S PERSONNEL DIRECTLY INVOLVED IN THE TEST PROGRAM SHALL BE ALLOWED TO WITNESS TESTING OR INSPECT, PHOTOGRAPH OR VIDEOTAPE ANY TEST VEHICLE UNLESS AUTHORIZATION IS GRANTED BY A REPRESENTATIVE FROM THE OCWS. IT IS THE CONTRACTOR'S RESPONSIBILITY TO SECURE THE TEST SITE AREA DURING A TEST AND TO SHIELD THE TEST AREA FROM

THE PUBLIC VIEW BY THE USE OF CANVAS OR OTHER BLOCKING DEVICES.

3.1 RULES FOR CONTRACTORS

A. No vehicle manufacturer's representative(s) or anyone other than the Contractor's personnel working on NHTSA contracts and NHTSA personnel shall be allowed to inspect NHTSA vehicles or witness vehicle preparations and/or crash testing without prior permission of the OCWS. Such permission can never be assumed.

B. All communications with vehicle manufacturers shall be referred to the OCWS, and at no time shall the Contractor release test data, videos, or photos without the permission of the OCWS

C. Unless otherwise specified, the vehicle manufacturer's representatives shall only be authorized to visit the Contractor's test facility on the day that the test is scheduled, and the representatives must be escorted by NHTSA and/or Contractor personnel.

D. Test vehicle inspection by the vehicle manufacturer's representative(s) shall be limited to 30 minutes prior to the start of the test. Post-test inspection shall be limited to 1 hour after Contractor personnel have completed their test tasks.

NOTE: No vehicle parts should be tampered with or removed from the vehicle without the consent of the COR.

E. Photographs and video of the test vehicle, associated test equipment, and test event shall be allowed. However, test personnel shall not be included in any photographic coverage, and videos of vehicle preparation at the vehicle manufacturer's request must be approved by OCWS. The Contractor's personnel shall not respond to any questions from the manufacturer's representatives regarding NHTSA. All questions shall be referred to the COR, an OCWS representative present at the test site, or to OCWS.

F. The Contractor shall permit public access to and inspection of the test vehicles and related data during times specified by the NHTSA COR. NHTSA shall advise interested parties that such access and inspection shall be limited to a specified day and hours and require prior approval from the Office of Crashworthiness Standards. This service shall be included as an incidental part of the test program and will not result in any additional cost to the NHTSA. The Contractor shall make his own arrangements with interested parties for expenses incurred beyond providing access and inspection services. All inquiries by manufacturers concerning NHTSA (vehicle, procedures, data, etc.…) shall be directed to OCWS representatives.

4. GOOD HOUSEKEEPING

Contractors shall maintain the entire vehicle testing area, test fixtures and instrumentation in a neat, clean, and painted condition with test instruments arranged in an orderly manner consistent with good test laboratory housekeeping practices.

5. TEST SCHEDULING AND MONITORING

Tests shall be completed as required in the contract. The COR will make adjustments to the test schedule in cases of unusual circumstances, such as inclement weather. All testing shall be coordinated to allow monitoring by the COR.

6. FACILITY AND EQUIPMENT

6.1 TEST VEHICLE PREPARATION AND INSPECTION BUILDING

The Contractor shall have a temperature controlled building large enough to house the test vehicle and allow for government, vehicle manufacturer, and laboratory personnel to move around as needed. The building climate control must maintain the ambient air temperature between 10 °C and 30 °C.

6.2 FULL VEHICLE TEST CHAMBER

Test chamber sized appropriately to contain the test vehicle, with climate control capable of maintaining the ambient air temperature between 40 °C and 45 °C.

6.3 EXTERNAL SHORT CIRCUIT

The Contractor shall have equipment capable of providing a short connection to the vehicle via a breakout harness. The resistance of the connection shall not exceed 5 mΩ. A shunt, or equivalent method, shall be incorporated into the short circuit contactor for the purpose of measuring and recording current during the test.

6.4 HIGH VOLTAGE BATTERY TEST SYSTEM

A high voltage battery test system, or combination of systems, shall be employed by the lab capable of supplying the charging and discharging voltage, current, and power required by the manufacturer.

6.5 ELECTRICAL ISOLATION MEASUREMENT

The voltmeter(s) used in this test shall measure AC and DC values and have an internal impedance of at least 10MΩ.

Voltage measurements throughout this test must be made quickly and safely. To ensure these requirements are met, the testing lab must devise, for COR approval, a test interface port or other device to facilitate these voltage measurements. All voltage measurements shall be immediate upon connection to the interface port. This test interface port equipment shall be easily accessible from the exterior of the vehicle and connected to the appropriate propulsion system and battery components via laboratory installed wires. The external mounting of this test interface port shall be configured such that no movement, interference, or damage will result to it from a barrier crash test. The test interface port shall incorporate a fusible link and any other necessary safety device or usage procedure to protect the data measurement and

recording equipment from damage, and the test technicians from electrical shock.

A terminal block or circuit board is recommended as a means to providing an external interface.

The following is an example quoted from Transport Canada document, "Test Procedures, Frontal Impact 208-212-301F-305F, No. 03-002"

"This kit is composed of a PVC box compliant with the electrical code and containing insulated banana connectors that allow the measuring equipment to be connected for the verification of the standard. A warning light indicates the presence of voltage inside the box. A shielded cable with three conductors, 20 feet in length and capable of supporting 600 volts, connects the box to the vehicle's electrical system. This cable is covered with orange-coloured mechanical protection (similar to the Hybrid vehicle high-voltage identification code). The box is protected by a 0.5-amp fuse."

6.6 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The facility shall be equipped with high-voltage protection gloves, nonconductive shoes, eye protection and any other safety equipment deemed necessary to safely prepare the vehicle and conduct the test.

7. GOVERNMENT FURNISHED PROPERTY (GFP)

7.1 TEST VEHICLES

A. The Contractor has the responsibility of accepting NHTSA-provided test vehicles. The Contractor acts on NHTSA's behalf when signing an acceptance of test vehicles. The Contractor must check to verify the following:

1. All options listed on the "window sticker" are present on the test vehicle.
2. Tires and wheel rims are the same as listed.
3. There are no dents or other interior or exterior flaws.
4. The vehicle has been properly prepared and is in running condition.
5. The glove box contains an owner's manual, warranty document, consumer information, and extra set of keys.
6. Proper fuel filler cap is supplied with the test vehicle (if applicable).
7. Verify that spare tire, jack, lug wrench, and tool kit (if applicable) are located in the vehicle cargo area.
8. The Contractor shall check for damage that may have occurred during transit. The COR is to be notified of any damage prior to preparation of the vehicle for testing.
9. The vehicle is equipped with the specified drivetrain (e.g. hybrid, plugin hybrid, or full electric) and specified charging options (e.g. optional DC fast charging).
10. Ensure any required proprietary charging cables are included.

8. CALIBRATION AND TEST INSTRUMENTATION

Before the Contractor initiates the test program, a test instrumentation calibration system must be implemented and maintained in accordance with established calibration practices. The calibration system shall include the following as a minimum:

A. Standards for calibrating the measuring and test equipment will be stored and used under appropriate environmental conditions to assure their accuracy and stability.

B. All measuring instruments and standards shall be calibrated by the Contractor, or a commercial facility, against a higher order standard at periodic intervals not exceeding 12 months for instruments and 12 months for the calibration standards. Record, showing the calibration traceability to the National Institute of Standards and Technology (NIST), shall be maintained for all measuring and test equipment.

C. All measuring and test equipment and measuring standards will be labeled with the following information:

1. Date and place of last calibration
2. Date of next scheduled calibration
3. Name of the technician or commercial facility performing the calibration
4. Full-scale measurement range
5. Accuracy and tolerance over the entire measurement range (or within the range used for testing)

D. A written calibration procedure shall be provided by the Contractor, which includes as a minimum the following information for all measurement and test equipment:

1. Type of equipment, manufacturer model, ext.
2. Measurement range
3. Accuracy
4. Calibration interval
5. Type of standard used to calibrate the equipment (calibration traceability of the standard must be evident)
6. The actual procedures and forms used to perform the calibrations.

E. Records of calibration for all test instrumentation shall be kept by the Contractor in a manner that assures the maintenance of established calibration schedules.

F. All such records shall be readily available for inspection when requested by the COR. The history of the record shall be updated in an electronic file. The calibration systems will need acceptance of the COR before testing commences.

G. Test equipment shall receive a system of functional check-out using a known test input before and after the test. This check shall be recorded by the test technician(s) and submitted to the COR upon request.

H. The Contractor-Furnished data acquisition system (DAS) shall have a sufficient number of channels available for recording and processing signals from the vehicle and test equipment sensors.

9. PHOTOGRAPHIC DOCUMENTATION

9.1 CAMERAS AND VIDEO REQUIREMENTS

Video files should be submitted to the NHTSA FTP site in MPEG-4 format with a standard or generally available "codec". Other types of files can be used if approved by the COR and formatted using a standard or generally available "codec".

Real Time Cameras

The Contractor may use a real-time camera to document various test items. If a real-time camera is used it should be shot in color at either 24, 30, or 60 frames per second. The digital file delivered to NHTSA should be .avi, .mpeg, or .wmv with a standard and generally available codec. The test laboratory's name and logo should not appear in the real-time video.

9.2 VEHICLE INFORMATION PLACARDS

Vehicle identification placards shall be position so that at least 1 placard will be visible in the field-of-view for each real time camera image. The following information will be shown, along with an indication of whether the view shown is pre- or post-test:

Vehicle's NHTSA Number
Description of test mode
Date of test
Vehicle year, make and model

Note: The name of the test laboratory should not be present on any vehicle placards used in photos and videos submitted to NHTSA.

9.3 STILL PHOTOGRAPHS

Clear and properly focused digital still photographs in .jpg format with minimum dots-per-inch (DPI) of 300 shall be taken to document the test. A vehicle information placard, identifying the test vehicle model as well as the NHTSA number, along with an indication of whether the photo was taken pre-test or post-test, shall appear in each relevant photograph and be legible. A time/date stamp of each photo is also highly recommended. Each photograph shall also be labeled when transferred to the FTP site as part of the Quality Control Package. In addition, the photos should be labeled in Appendix A of the final test report. A list of required photographs with their labeling convention can be found in **Appendix B** to this procedure.

10. DEFINITIONS

The contractor shall check the current revision of GTR No. 20 for the most recent definitions.

A. Ready Mode: a mode in which the high voltage is supplied to the electrical powertrain but application of pressure to the accelerator pedal will not cause the vehicle to move.

B. Accessible: referring to a part, component, or area which can be reached by one of the access probes (IPXXD, IPXXB) without being visible.

C. HV Location(s): accessible components, part, or connectors that can contain "*high voltage*" as defined by the GTR No. 20.

D. Removable Part(s): parts or components which can be opened, disassembled or removed without the use of tools and without affecting any voltage measurements taken after the part or components removal.

11. TEST EXECUTION

At the start of a contract, testing shall not begin until the COR approves the Contractor's in-house test procedure.

Prior to conducting any testing, the Contractor shall:

1. Verify the training of technicians for performance of the test,
2. Verify the calibration status of test equipment,
3. Review applicable revisions of test procedures, and
4. Review vehicle Owner's Manual (or equipment mfg. instructions)

11.1 TEST VEHICLE PREPARATION

A. TEST VEHICLE INFORMATION

Using the owner's manual, certification labels, information provided by the COR and any other data available, determine the following vehicle information and record on Data Sheet No. 1.

1. Model year, make, model and body style
2. Body Color and VIN
3. NHTSA No. (supplied by NHTSA)
4. Build date (or moth and year of manufacture)
5. Current odometer reading
6. Vehicle Capacity Weight
7. Type of Electric Vehicle (HEV, PHEV, EV)
8. REESS type, nominal voltage, maximum state of charge
9. REESS electrolyte fluid type, specific gravity, kinematic viscosity, and color
10. REESS coolant type, color, and specific gravity (if applicable)
11. Physical location of REESS service disconnect (if applicable)
12. Auxiliary battery type (if applicable)

11.2 PROTECTION AGAINST ELECTRICAL SHOCK (5.1.1.)

A. VEHICLE PREPARATION

Verify that the vehicle is not connected to an external power supply or charger. Close all vehicle charging port doors.

The vehicle shall be soaked at 20 ± 10 °C until the vehicle exterior and interior maintain this temperature for a minimum of 30 minutes prior to any testing or evaluations.

Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle can achieve "ready mode". Verify all HV systems are functional. Document/photograph any indication to the driver of the SOC of the REESS.

B. PROTECTION AGAINST DIRECT CONTACT

IMPORTANT: Use caution throughout the direct contact procedure and assume high voltage is present in the vehicle, use appropriate PPE.

1. Power down the vehicle, if applicable.

2. Identify all accessible components and connectors located within the passenger compartment and luggage compartment that might contain high voltage using visual inspection and manufacturer supplied information. These components and connectors shall hereinafter be referred to as "HV locations". Photograph and record the HV locations on the applicable data sheet.

   NOTE: Connectors that are provided with a locking mechanism (at least two distinct actions are needed to separate the connector from its mating component) are exempt.

   NOTE: 120V outlets are exempt from the requirements of this section.

3. Conduct IPXXD probe inspection on each HV location following the procedure in **Appendix A**, and record the results on the applicable data sheet.

4. Identify all HV locations located outside the passenger compartment and luggage compartment using visual inspection and manufacturer supplied information. Photograph and record the HV locations on Data Sheet No. 2.

   NOTE: A vehicle lift may be required to access and inspect the vehicle underbody.

   NOTE: Connectors that are provided with a locking mechanism (at least two distinct actions are needed to separate the connector from its mating component) are exempt.

5. Conduct IPXXB probe inspection on each HV location outside of the passenger compartment and luggage compartment following the procedure in **Appendix A**, and record the results on Data Sheet No. 2.

C. SERVICE DISCONNECT

IMPORTANT: Use caution throughout the service disconnect procedure and assume high voltage is present in the vehicle, use appropriate PPE.

1. Photograph the service disconnect and surrounding area, if equipped on the vehicle.

2. Review procedure for opening, disassembling, or removing the service disconnect in the owner's manual or manufacturer supplied information. If the service disconnect can be accessed and removed without the use of tools, proceed with the remaining steps of the procedure, otherwise the evaluation is complete.

3. Open, disassemble, or remove any applicable components or parts necessary to access the service disconnect (without the use of tools). Take an additional photograph of the fully accessible service disconnect, if applicable.

4. Open, disassemble, or remove the service disconnect (without the use of tools) and photograph the service disconnect and surrounding area.

5. Conduct IPXXB probe inspection on each HV location at the service disconnect following the procedure in **Appendix A**, and record the results on Data Sheet No. 2.

D. MARKINGS

1. Identify the REESS and all enclosures, electrical protection barriers and cables for high voltage buses located outside an enclosure using visual inspection and manufacturer supplied information. Without using any tools open, disassemble, or remove all parts and components that can be opened, disassembled, or removed in order to access the REESS, enclosures, electrical protection barriers, and high voltage cables.

   NOTE: A vehicle lift may be required to access and inspect the vehicle underbody.

2. Photograph and record all identified locations on Data Sheet No. 2.
   a. For components, enclosures, and electrical protection barriers record the presences of the symbol shown in Figure 1.
   b. For high voltage cables record the presence of an outer covering with the color orange.

E. PROTECTION AGAINST INDIRECT CONTACT

IMPORTANT: Use caution throughout the indirect contact procedure and assume high voltage is present in the vehicle, use appropriate PPE.

1. Power down the vehicle, if applicable.

2. Identify all HV locations with exposed conductive parts on the vehicle exterior or interior using visual inspection and manufacturer supplied information. Open, disassemble, or remove all removable parts located on the vehicle exterior or interior without the use of tools.

   NOTE: A vehicle lift may be required to access and inspect the vehicle underbody.

3. Photograph and record all identified locations on Data Sheet No. 2.

4. Record the grounding method for all identified locations on Data Sheet No. 2.

5. Conduct a resistance evaluation of all identified locations following either Resistance Tester or DC Power Supply procedure in **Appendix A**, and record the results on Data Sheet No. 2.

F. GROUNDED EXTERNAL CHARGING

1. Power down the vehicle, if applicable.

2. Identify the location of the ground point on the vehicle connector and the vehicle inlet using visual inspection and manufacturer supplied information.

3. Connect the vehicle connector to the vehicle inlet following the charging procedure provided by the manufacturer. Confirm the ground connection is closed before the HV connections are closed using a manufacturer supplied method, visual inspection, or part drawings.

4. Photograph the grounding point on the vehicle inlet and document the results of the evaluation on Data Sheet No. 2.

G. ISOLATION

IMPORTANT: Use caution throughout the isolation resistance procedure and assume high voltage is present in the vehicle, use appropriate PPE.

1. Power down the vehicle, if applicable.

2. Install the electrical isolation resistance test interface port following the manufacturer's instructions.

3. Review manufacturer supplied information and the vehicle configuration to identify all high voltage buses and determine which of the following are present:

   a. Electrical power train consisting of conductively isolated DC or AC buses

b. Electrical power train consisting of conductively connected DC and AC buses

4. Measure the isolation resistance for each applicable high voltage bus following the Isolation Resistance Measurement Procedure in **Appendix A**.

5. Record the isolation resistance values on Data Sheet No. 2.

6. For fuel cell vehicles, verify presence and activation of an onboard isolation resistance monitoring system by placing an appropriate resistor, as defined by GTR 20 Section 6.2.1, between the main HV positive bus of the electrical power train and the vehicle chassis to create an isolation resistance below the monitoring system's threshold. Document the resistor size, isolation resistance, and monitoring system's response on Data Sheet No. 2.

7. For vehicles equipped with external charging connections, measure the isolation resistance for each high voltage live part of the vehicle inlet following the Isolation Resistance Measurement Procedure in **Appendix A**. Record the external charger inlet isolation resistance values on Data Sheet No. 2.

11.3 FUNCTIONAL SAFETY (5.1.2.)

A. VEHICLE PREPERATION

Verify that the vehicle is not connected to an external power supply or charger. Close all vehicle charging port doors.

The vehicle shall be soaked at 20 ± 10 °C until the vehicle exterior and interior maintain this temperature for a minimum of 30 minutes prior to any testing or evaluations.

Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle can achieve "ready mode". Verify all HV systems are functional. Document/photograph any indication to the driver of the SOC of the REESS.

B. MOMENTARY INDICATION WHEN PLACED IN ACTIVE DRIVING MODE

1. If an internal combustion engine directly or indirectly provides the vehicle's propulsion power upon startup the evaluation is complete, otherwise proceed with the following steps.

2. Install a real time camera to record any indications to the driver and start recording.

3. Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle is in ready mode. Verify that the vehicle is not in active driving possible mode by depressing the accelerator pedal and observing no vehicle movement. Record any visible and/or audible indications to the driver on the applicable data sheet.

4. Depress the brake pedal (if applicable) and place the vehicle in the forward active driving mode. Verify that the electric power train will move the vehicle by releasing the brake pedal (if applicable) and activating the accelerator pedal until forward vehicle movement is observed. Record any visible and/or audible indications to the driver on the applicable data sheet.

5. Take the vehicle out of active driving possible mode and power down/turn off the vehicle.

6. Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle is in ready mode. Verify that the vehicle is not in active driving possible mode by depressing the accelerator pedal and observing no vehicle movement.

7. Depress the brake pedal (if applicable) and place the vehicle in the reverse active driving mode. Verify that the electric power train will move the vehicle by releasing the brake pedal (if applicable) and activating the accelerator pedal until reverse vehicle movement is observed. Record any visible and/or audible indications to the driver on Data Sheet No. 3

8. Stop recording the real time camera.

C. DRIVER TO BE INFORMED WHEN LEAVING VEHICLE

IMPORTANT: Use caution when leaving the vehicle while in active driving mode.

1. Install wheel stops to prevent vehicle movement during the evaluation.

2. Install a real time camera to record any indications to the driver and start recording.

3. Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle is in ready mode.

4. Depress the brake pedal (if applicable) and place the vehicle in the forward active driving mode.

5. Release the brake pedal (if applicable), then open the driver door and observe any indication from the vehicle that it is still in the active driving possible mode. Record any visible and/or audible indications to the driver on Data Sheet No. 3.

6. Close the driver door, take the vehicle out of active driving mode and power down/turn off the vehicle.

7. Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle is in ready mode.

8. Depress the brake pedal (if applicable) and place the vehicle in the forward active driving mode.

9. Open the driver door, then release the brake pedal (if applicable) and observe any indication from the vehicle that it is still in the active driving possible mode. Record any visible and/or audible indications to the driver on Data Sheet No. 3.

10. Close the driver door, take the vehicle out of active driving mode and power down/turn off the vehicle.

11. Repeat steps 3 – 10 for the reverse active driving mode.

D. STATE OF DRIVE DIRECTION IDENTIFICATION

1. Install wheel stops to prevent vehicle movement during the evaluation.

2. Install a real time camera to record any indications to the driver and start recording.

3. Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle is in ready mode.

4. Depress the brake pedal (if applicable) and place the vehicle in the forward active driving mode. Record any visible and/or audible indications to the driver on Data Sheet No. 3.

5. Take the vehicle out of active driving mode.

6. Depress the brake pedal (if applicable) and place the vehicle in the reverse active driving mode. Record any visible and/or audible indications to the driver on Data Sheet No. 3.

7. Take the vehicle out of active driving mode and power down/turn off the vehicle.

D. VEHICLE MOVEMENT WHILE EXTERNALLY CHARGING

1. Review the owner's manual or manufacturer's provided information to determine if the RESS be externally charged. If the vehicle cannot be externally charged the evaluation is complete, otherwise proceed with the following steps for each type of charger available for the vehicle.

2. Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle is in ready mode. Verify that the state of charge (SOC) of the REESS is below 90% of its full operating range.

3. Depress the brake pedal (if applicable) and place the vehicle in the forward active driving mode. Verify that the electric power train will move the vehicle by releasing the brake pedal (if applicable) and activating the accelerator pedal until forward vehicle movement is observed.

4. Take the vehicle out of active driving mode and power down/turn off the vehicle.

5. Attach a plumb bob or similar device in indicate vehicle position at the front and rear centerline of the vehicle. Mark the starting location of the vehicle in front and back with reference to the ground.

6. Connect the appropriate vehicle charger connector to the vehicle charge port following the owner's manual or manufacturer supplied information. Verify that the vehicle is actively charging before proceeding.

7. Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle is in ready mode. Depress the brake pedal (if applicable) and place the vehicle in the forward active driving mode.

NOTE: Ensure all occupant doors and cargo hatches not required for charging remain closed during the next step.

8. Release the brake pedal (if applicable) and depress the accelerator pedal. If the vehicle moves, stop the vehicle movement after approximately three (3) feet.

9. Take the vehicle out of active driving mode and power down/turn off the vehicle. Record the vehicle movement from its initial position on Data Sheet No. 3.

10. Repeat steps 5 and 7 – 9 for the reverse active driving mode.

11. Remove the charger and close the charging port door.

12. Repeat steps 5 – 11 using other chargers available for the vehicle (e.g. L1, L2, DC Fast Charger).

11.4 FUNCTIONALITY OF REESS IN A VEHICLE (5.3.)

A. VEHICLE PREPERATION

Verify that the vehicle is not connected to an external power supply or charger. Close all vehicle charging port doors.

The vehicle shall be soaked at 20 ± 10 °C until the vehicle exterior and interior maintain this temperature for a minimum of 30 minutes prior to any testing or evaluations.

Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle can achieve "ready mode". Verify all HV systems are functional. Document/photograph any indication to the driver of the SOC of the REESS.

B. WARNING IN THE EVENT OF OPERATIONAL FAILURE OF VEHICLE CONTROLS THAT MANAGE THE SAFE OPERATION OF THE REESS

1. Review information provided by the vehicle manufacturer. The information shall contain one of the following:

    a. A system diagram that identifies all the vehicles controls that manage REESS operations and identifies what components are used to generate a warning.
    b. A written explanation describing the basic operation of the vehicle controls that manage REESS operation. The manufacturer must identify the functions and capability to manage the REESS, and provide a logic diagram and description of conditions that would lead to triggering of the warning.

2. For systems with an audible or visual indication during power up, capture this indication using a real time camera during power up.

3. Record a description of the warning to the driver on Data Sheet No. 4.

C. WARNING IN THE EVENT OF A THERMAL EVENT WITHIN THE REESS

1. Review information provided by the vehicle manufacturer. The information should contain both of the following:

    a. Parameters and associated threshold levels that are used to indicate a thermal event to trigger the warning.
    b. A system diagram and written explanation describing the sensors and operation of the vehicle controls to manage the REESS in the event of a thermal event.

2. For systems with an audible or visual indication during power up, capture this indication using a real time camera during power up.

3. Record a description of the warning to the driver on Data Sheet No. 4.

D. WARNING IN THE EVENT OF LOW ENERGY CONTENT OF REESS

1. Review the owner's manual and information provided by the vehicle manufacturer. The information should contain at least one of the following:

    a. Voltage level that triggers the low energy tell-tale lamp
    b. SOC level that triggers the low energy tell-tale lamp
    c. Range remaining level that triggers the low energy tell-tale lamp

2. For systems with an audible or visual indication during power up, capture this indication using a real time camera during power up.

3. Record a description of the warning to the driver on Data Sheet No. 4.

11.5 REESS SAFETY – IN USE (5.4.)

In-use testing will be performed using the full vehicle methods prescribed in GTR 20 with the use of a break-out harness and laboratory test equipment. The vehicle manufacturer will provide instructions for installing the break-out harness on the traction side, and the break-out harness will have provisions for attached the necessary test equipment. The diagram below illustrates this common setup method for in-use test cases.

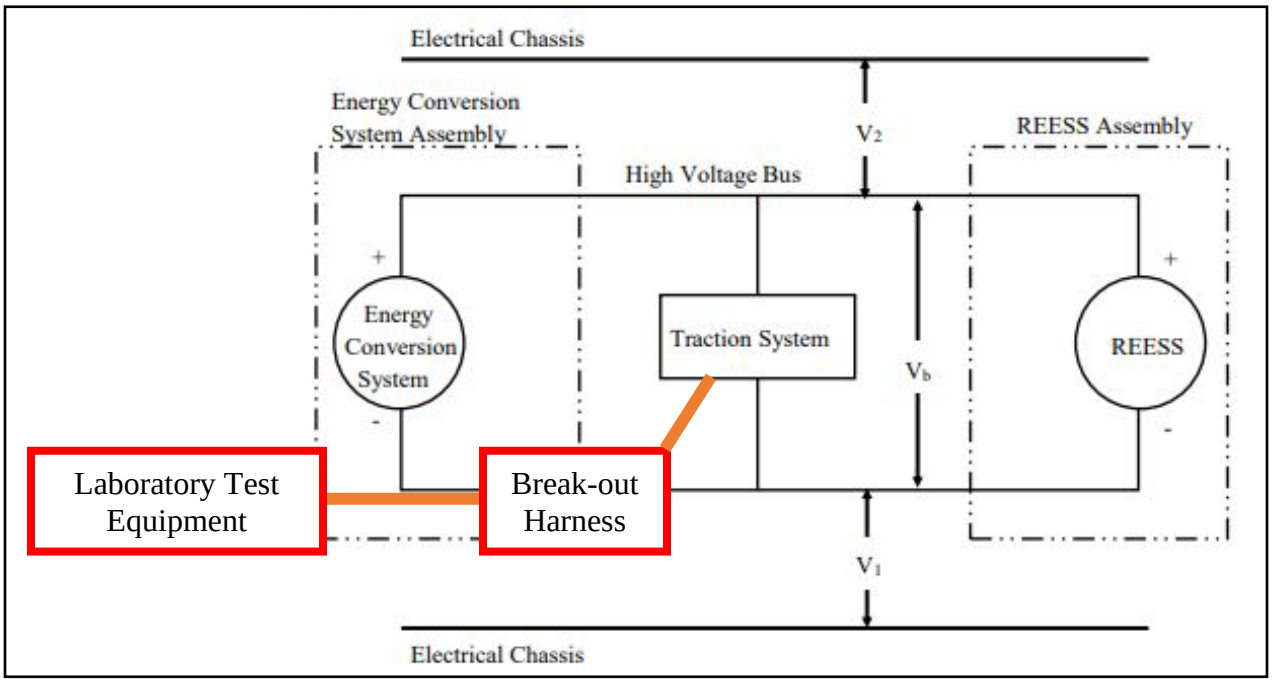


Figure 2- In-use Break-out Harness Test Setup

A. EXTERNAL SHORT CIRCUIT PROTECTION

1. Review the owner's manual or manufacturer's provided information to determine the maximum state of charge (SOC) of the vehicle. For vehicles that can be externally charged, identify which type of charging will provide the maximum SOC. For vehicles that are only rechargeable using an energy source on the vehicle, identify the manufactures method to reach the maximum SOC.

2. Soak the test vehicle or REESS components at in 20 ± 10 °C temperature for 4 hours. Power up the vehicle/REESS and record the SOC of the vehicle/REESS on Data Sheet No. 5. If the SOC is ≥ 95% proceed to Step 4.

3. Charge the REESS until SOC is ≥ 95% following one of the following methods. Record the final SOC on Data Sheet No. 5 after charging.

    a. For a vehicle with a REESS designed to be externally charged, the REESS shall be charged to the highest SOC in accordance with the procedure specified by the manufacturer for normal operation until the charging process is normally terminated.

b. For a vehicle with a REESS designed to be charged only by an energy source on the vehicle, the REESS shall be charged to the highest SOC which is achievable with normal operation of the vehicle. The manufacturer shall advise on the vehicle operation mode to achieve this SOC.

c. In case that the REESS or REESS sub-system is used as the tested device, the tested device shall be charged to the highest SOC in accordance with the procedure specified by the manufacturer for normal operation until the charging process is normally terminated. Procedures specified by the manufacturer for manufacturing, service or maintenance may be considered as appropriate if they achieve an equivalent SOC as for that under normal operating conditions. In case that tested device does not control the SOC by itself, the SOC shall be charged to not less than 95 per cent of the maximum normal operation SOC defined by the manufacturer for the specific configuration of the tested device

4. For full vehicle testing, power up/turn on the vehicle and ensure full operation of the REESS and all subsystems. Document any warning lamps or vehicle faults relating to the electrical power train that are present. Before proceeding, review any warning lamps/faults with the COR and manufacturer to ensure all protection devices are functioning for the REESS before proceeding.

IMPORTANT: Ensure all equipment is capable of High current level that can be generated during testing.

5. Connect the manufacturer provided breakout harness to the short circuit contactor.

6. Using a milliohm meter, measure the total resistance of the equipment used for creating the external short circuit and record the value on Data Sheet No. 5.

7. Install the breakout harness on the traction side of REESS following directions provided by the manufacturer.

IMPORTANT: Use caution throughout the breakout harness installation and assume high voltage is present in the vehicle, use appropriate PPE.

8. Install temperature probes on the case of the REESS or directly on the inside the REESS. As an alternative, temperature measurements may be obtained through communication with the REESS control module if a communication method is known or supplied by the manufacturer.

9. Install voltage and current monitoring sensors on the short circuit contactor for monitoring and recording the current through the short and REESS voltage during the test. REESS voltage values may be obtained through communication with the REESS control module if a method is known or supplied by the manufacturer.

10. Verify that all data acquisition and video equipment is recording prior to proceeding with the test.

11. Conduct the short circuit test by closing the contactor.

12. Open the contactor after either:

    a. Current is no longer present

    b. 1 hour after REESS temperature has stabilized, defined as a temperature change of less than 4 °C for a 2-hour period.

    c. Any evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

13. Perform a standard cycle immediately following the test, if not inhibited by the vehicle.

14. Observe the vehicle for 1 hour for any signs of failure.

15. Perform an isolation resistance evaluation and record the electrical isolation value on Data Sheet No. 5.

16. Remove the breakout harness and take any necessary actions to return the vehicle to normal operation condition for further testing.

B. OVERCHARGE PROTECTION

1. Increase the SOC of the vehicle in accordance with the procedure specified by the manufacturer for normal operation until the charging process is normally terminated, or to a level specified by the COR. The COR may determine a specific SOC based on estimated test duration, REESS capacity, or manufacturer specified charging procedure.

2. For vehicle's with on-board energy conversion systems (e.g. internal combustion engine, fuel cell, etc.), verify that the fuel system has sufficient supply to allow operation of the energy conversion system. Record the level of the fuel system supply on Data Sheet No. 6.

3. Soak the test vehicle or the REESS (where applicable) at 20 ± 10 °C for 4 hours.

4. Record the initial SOC on Data Sheet No. 6.

5. Create a safety perimeter surrounding the vehicle which provides adequate space/protection against a thermal event.

6. Install the breakout harness on the traction side following directions provided by the NHTSA COR or vehicle manufacturer. Connect the breakout harness to the laboratory equipment that will supply the overcharge.

IMPORTANT: Use caution throughout the breakout harness installation and assume high voltage is present in the vehicle, use appropriate PPE.

7. Install temperature probes on the case of the REESS or directly on the inside the REESS. As an alternative, temperature measurements may be obtained through communication with the REESS control module if a method is supplied by the manufacturer.

8. Install voltage and current monitoring sensors on the charging equipment for monitoring and recording the external voltage and current supplied during the test. These values may be recorded by the battery tester equipment.

9. Review the manufacturer's supplied test method and ensure that the charging equipment is rated at least 10% higher than the maximum values in the test method. Program the appropriate settings on the test equipment to supply the specified voltage, current, and power. Record these settings on Data Sheet No. 6.

10. Verify that all data acquisition and video equipment is recording prior to proceeding with the test.

11. Conduct the test by supplying the overcharge to the vehicle breakout harness.

12. Terminate the overcharge after either:

    a. The vehicle's overcharge protection control terminates the REESS charge current.

    b. The REESS temperature is 10 °C above its maximum operating temperature.

    c. 12 hours elapse since the start of the overcharge supply in step 11.

    d. Any evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

13. Perform a standard cycle immediately following the test, if not inhibited by the vehicle.

14. Observe the vehicle for 1 hour for any signs of failure.

15. Perform an isolation resistance evaluation and record the electrical isolation value on Data Sheet No. 6.

16. Remove the breakout harness and take any appropriate actions to return the vehicle to normal operation condition for further testing.

C. OVER-DISCHARGE PROTECTION

1. Adjust the SOC of the vehicle to 10% +/- 1% SOC following the manufacturer recommended charging and discharging procedure.

2. For vehicle based testing with on-board energy conversion systems (e.g. internal combustion engine, fuel cell, etc.), reduce the amount of fuel supply to the minimum level where active driving mode is permitted. Record the level of the fuel system supply on Data Sheet No. 7.

3. Soak the test vehicle or the REESS (where applicable) at 20 ± 10 °C for 4 hours.

4. Record the initial SOC on Data Sheet No. 7.

5. Create a safety perimeter surrounding the vehicle which provides adequate space/protection against a thermal event.

6. Install the breakout harness on the traction side following directions provided by the manufacturer. Connect the breakout harness to the laboratory equipment that will supply the discharge.

IMPORTANT: Use caution throughout the breakout harness installation and assume high voltage is present in the vehicle, use appropriate PPE.

7. Install temperature probes on the case of the REESS or directly on the inside the REESS. As an alternative, temperature measurements may be obtained through communication with the REESS control module if a method is supplied by the manufacturer.

8. Install voltage and current monitoring sensors on the discharging equipment for monitoring and recording the external voltage and current discharged during the test. These values may be recorded by the battery tester/discharge equipment.

9. Program the appropriate settings on the test equipment to supply the specified discharge voltage, current, and power. Record these settings on Data Sheet No. 7.

10. Verify that all data acquisition and video equipment is recording prior to proceeding with the test.

11. Conduct the test by supplying the discharge to the vehicle breakout harness.

12. Terminate the discharge after either:

    a. The vehicle's over-discharge protection control terminates the REESS discharge current.

    b. The REESS temperature is stabilized, such that the temperature varies by a gradient of less than 4°C through a 2-hour period.

    c. The REESS is discharged to 25% of its nominal voltage level.

13. Perform a standard cycle immediately following the test, if not inhibited by the vehicle.

14. Observe the vehicle for 1 hour for any signs of failure.

15. Perform an isolation resistance evaluation and record the electrical isolation value on Data Sheet No. 7

16. Remove the breakout harness and take any necessary actions to return the vehicle to normal operation condition for further testing.

D. OVER-TEMPERATURE PROTECTION

1. Adjust the SOC of the vehicle to the initial SOC recommended by the manufacturer's test method, following the manufacturer recommended charging and discharging procedure. If the initial SOC is not specified, adjust SOC to 95% +/- 5%.

2. For vehicle based testing with on-board energy conversion systems (e.g. internal combustion engine, fuel cell, etc.), verify that the fuel system has sufficient supply to allow operation of the energy conversion system for the 3 hours of testing. Record the level of the fuel system supply on Data Sheet No. 8.

3. Disable, or significantly reduce the operation of (for an REESS that will not operate if the cooling system is disabled), the REESS cooling system following the manufacturer's instructions. The cooling system should have zero to very little impact on the final results of the test. Methods for disabling the cooling system may include crimping the liquid cooling hose or in the case of a refrigerant cooled package, removing the refrigerant fluid. Consult with the manufacturer to determine appropriate method for disabling the vehicle's cooling system.

4. Install temperature probes on the case of the REESS or directly on the inside the REESS. As an alternative, temperature measurements may be obtained through communication with the REESS control module if a method is supplied by the manufacturer.

5. Soak the test vehicle at 40-45 °C for a minimum of 6 hours.

6. Verify REESS temperature is 42 ± 5° before proceeding. Record the initial REESS temperature in Data Sheet No. 8.

7. Install the vehicle on a chassis dynamometer and place the vehicle in driving mode. If external charging is used in the manufacturer's test method, prepare the charging equipment and connect to the vehicle as detailed in the manufacturer's test method.

8. Create a safety perimeter surrounding the vehicle which provides adequate space/protection against a thermal event

9. Verify that all data acquisition and video equipment is recording prior to proceeding with the test.

10. Conduct the test by performing the specified driving and charging profiles supplied by the manufacturer.

11. Terminate the driving and/or charging profiles after either:

    a. The vehicle terminates the charge and/or discharge.

    b. The REESS temperature is stabilized, such that the temperature varies by a gradient of less than 4°C through a 2-hour period.

    c. Any evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

    d. 3 hours elapse from the start of the charge/discharge cycles started in step 10.

17. Perform an isolation resistance evaluation and record the electrical isolation value on Data Sheet No. 8.

18. Enable the REESS cooling system and take any necessary actions to return the vehicle to normal operation condition for further testing.

E. OVERCURRENT PROTECTION

1. Adjust the SOC of the vehicle to 50% +/- 10% SOC following the manufacturer recommended charging and discharging procedure.

2. Soak the test vehicle or the REESS (where applicable) at 20 ± 10 °C for 4 hours.

3. Record the initial SOC on Data Sheet No. 9.

4. Create a safety perimeter surrounding the vehicle which provides adequate space/protection against a thermal event.

5. Install the breakout harness on the traction side of the REESS following directions provided by the manufacturer. Connect the breakout harness to the laboratory equipment that will supply the overcurrent.

IMPORTANT: Use caution throughout the breakout harness installation and assume high voltage is present in the vehicle, use appropriate PPE.

6. Install temperature probes on the case of the REESS or directly on the inside the REESS. As an alternative, temperature measurements may be obtained through communication with the REESS control module if a method is supplied by the manufacturer.

7. Install voltage and current monitoring sensors on the overcurrent equipment for monitoring and recording the external voltage and current supplied during the test. These values may be recorded by the battery tester/charging equipment.

8. Program the appropriate settings on the test equipment to supply the specified overcurrent voltage, current, and power. Record these settings on Data Sheet No. 9. The charge equipment should start at the maximum normal charge current and then increase over 5 seconds to the overcurrent level at the start of the test.

9. Verify that all data acquisition and video equipment is recording prior to proceeding with the test.

10. Conduct the test by supplying the overcurrent to the vehicle breakout harness.

11. Terminate the overcurrent after either:

    a. The vehicle's overcurrent protection control terminates charging.

    b. The REESS temperature is stabilized, such that the temperature varies by a gradient of less than 4°C through a 2-hour period.

    c. Any evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

12. Perform a standard cycle immediately following the test, if not inhibited by the vehicle.

13. Observe the vehicle for 1 hour for any signs of failure.

14. Perform an isolation resistance evaluation and record the electrical isolation value on Data Sheet No. 9.

15. Remove the breakout harness and take any necessary actions to return the vehicle to normal operation condition for further testing.

12. TEST DATA DISPOSITION

The Contractor shall make all test data available within two hours of the test event if so requested by NHTSA personnel. Under no circumstances shall this data be furnished to non-NHTSA personnel. The Contactor shall analyze the preliminary test results as directed by the COR.

12.1 TESTING ISSUES AND TEST DATA LOSS

A. TEST FAILURE DESCRIPTION

A test which fails to meet an applicable FMVSS or GTR performance requirement. See **Section 2, GENERAL REQUIREMENTS**.

B. TEST FAILURE NOTIFICATION

Any potential test failure notification shall be communicated by telephone to the COR within 24 hours with written notification emailed within 48 hours (Saturdays and Sundays excluded). A **Laboratory Notice of Invalid Test or Apparent Test Failure** (**Sheet 3** of **Appendix E**) with copies of the related test data sheet(s) and preliminary data (if applicable shall be included. In the event of a test failure, post-test calibration and/or qualification checks of critically sensitive test equipment and instrumentation may be required. The necessity for these verifications shall be at the COR's discretion and shall be performed without additional cost to the OCWS.

C. INVALID TEST DESCRIPTION

A test which does not conform precisely to all requirements and/or specifications of its respective test procedure and applicable contract and Statement of Work.

D. INVALID TEST NOTIFICATION

Any potentially invalid test shall be communicated by telephone to the COR withing 24 hours with written notification emailed within 48 hours (Saturdays and Sundays excluded). A **Laboratory Notice of Invalid Test or Apparent Test Failure** (**Sheet 3** of **Appendix E**) with copies of the related test data sheet(s) and preliminary data (if applicable shall be included. In the event of an invalid test, post-test calibration and/or qualification checks of some critically sensitive test equipment and instrumentation may be required. The necessity for these verifications shall be at the COR's discretion and shall be performed without additional cost to the OCWS.

E. RETEST NOTIFICATION

The Contracting Office of NHTSA is the only NHTSA official authorized to notify the Contractor whether a retest of an invalid test or test failure is required. In the event a retest due to an invalid test is required, it shall be performed at the Contractor's expense. The retest shall be completed no more than two (2) weeks after receipt of notification by the Contracting Officer unless an alternate timeframe is approved or directed by NHTSA.

F. WAIVER OF RETEST

NHTSA, in its sole discretion, reserves the right to waive the retest requirement. This provision shall not constitute a basis for dispute over the NHTSA's waiving or not waiving any requirement.

G. TEST VEHICLE

NHTSA shall furnish only one vehicle for each test series ordered. The Contractor shall furnish the test vehicle required for the retest if it is determined that the Contractor is at fault. The retest vehicle shall be equipped as the original vehicle. The original vehicle used

in the invalid test shall remain the property of NHTSA, and the retest vehicle shall remain the property of the Contractor. If a retest vehicle experiences a test anomaly or fails to meet any of the requirements of this test procedure, the Contractor shall retain the retest vehicle for a period not expected to exceed 180 days. If the retest is deemed valid, the Contractor may dispose of the vehicle upon notification from the COR that the final test report has been accepted.

H. TEST REPORT

No test report is required for any test which is determined to be invalid unless NHTSA specifically decides, in writing, to require the Contractor to submit such report. The test data from the invalid test must be safeguarded until the data from the retest has been accepted by the COR. The report and other required deliverables for the retest vehicle are required to be submitted to the COR within 3 weeks after completion of the retest.

I. DEFAULT

The Contractor is subject to the default and subsequent re-procurement cost for non-delivery of valid or conforming tests (pursuant to the Default clause in the contract).

J. CONDITIONS for PARTIAL PAYMENT

The Contractor shall exercise reasonable and foreseeable control to ensure that no data is lost or rendered useless. If some non-critical data and critical data are not obtained for the test and the test is accepted, NHTSA may not pay for the missing or lost data.

K. NHTSA'S RIGHTS

None of the requirements herein stated shall diminish or modify the rights of NHTSA to determine that any test submitted by the Contractor does not conform precisely to all requirements/specifications in the Laboratory Test Procedure and Statement of Work applicable to the test.

12.2 PERFORMANCE REQUIREMENTS – NOTIFICATION OF TEST RESULTS

The performance requirements are found in **Section 2** of this test procedure. If the test results indicate that the test vehicle has not met the requirements the Contractor shall notify the COR in accordance with **Appendix E, Test Deliverables and Report Guidelines**.

12.3 TEST DELIVERABLES

Required deliverables for each test are discussed in **Appendix E, Test Deliverables and Report Guidelines**. A Schedule of Deliverables is also provided at that location.

12.4 DATA RETENTION BY THE CONTRACTOR

The Contractor shall retain reproducible copies of all data tapes, digital videos, digital photographs, and **Sheet 1** manufacturer information for at least five (5) years (at no extra cost to the NHTSA).

The tested vehicles, protected from the elements, shall be retained by the test Contractor for a minimum of 60 days so that OCWS and vehicle manufacturer personnel may be given an inspection opportunity if needed.

12.5 DATA AVAILABILITY TO THE PUBLIC

The Contractor shall provide interested parties with copies of the test report, test CD's or DVDs, test data tapes, test videos, and test still photographs, at a reasonable cost to the purchaser, but only after the Office of Crashworthiness Standards representative has advised the Contractor that the results of that particular test have been released to the public by NHTSA.

APPENDIX A

SUPPORTING PROCEDURES
(PROTECTION DEGREE IPXXB, PROTECTION DEGREE IPXXD, RESISTANCE EVALUATIONS, STANDARD CYCLE, ISOLATION RESISTANCE MEASUREMENT)

APPENDIX A SUPPORTING PROCEDURES
TABLE OF CONTENTS

1. PROTECTION DEGREE IPXXB (GTR 20 Section 6.1.3.)

IMPORTANT: Use caution throughout the direct contact procedure and assume high voltage is present in the vehicle, use appropriate PPE.

1.1 DIRECT CONTACT BETWEEN HIGH VOLTAGE SOURCE AND CHASSIS

1. Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle is in "ready mode".

2. Connect one lead of a multimeter with a high resistance (10 MΩ), or a suitable lamp style tester, to the electrical chassis and the other lead to the IPXXB probe.

    a. Probe each HV location with the IPXXB probe joints in a straightened orientation.
    b. Probe the area with 10 ± 10% N until the probe contacts a HV part or until the probe cannot be pushed further. Do not allow the stop face to fully penetrate the electrical protection barrier (EPB).
    c. If the probe partly or fully penetrates the EPB, probe the area in every possible orientation with the probe joints in a straightened orientation. Proceed to probe the area in every possible orientation with the probe joints in a bent fashion with each joint bending up to 90 degrees relative to the adjacent joint.
    d. Record all voltages measured on the appropriate data sheet.

3. If any voltages measured are greater than or equal to 60V DC or 30V AC, high voltage is present: continue to section 1.2.

1.2 DIRECT CONTACT BETWEEN HIGH VOLTAGE SOURCES

1. Power down the vehicle and HV system

IMPORTANT: Before inspection, protect the area surrounding each location from step 1.1 that has HV present to prevent the probe from shorting HV to the vehicle chassis.

2. Connect one lead of a multimeter OR a low voltage supply with a continuity indicator to an exposed HV location and the other lead to the IPXXB probe.

    a. Probe each location from step 1.1 that has HV present
        i. Probe each location with the IPXXB probe joints in a straightened orientation.
        ii. Probe the area with 10 ± 10% N until the probe contacts a HV part or until the probe cannot be pushed further. Do not allow the stop face to fully penetrate the EPB.
        iii. If the probe partly or fully penetrates the EPB, probe the area in every possible orientation with the probe joints in a straightened orientation. Proceed to probe the area in every possible orientation with the probe joints

in a bent fashion with each joint bending up to 90 degrees relative to the adjacent joint.

iv. Document continuity measurements in the appropriate data sheet.

2. PROTECTION DEGREE IPXXD (GTR 20 Section 6.1.3.)

IMPORTANT: Use caution throughout the direct contact procedure and assume high voltage is present in the vehicle, use appropriate PPE.

2.1 DIRECT CONTACT BETWEEN HIGH VOLTAGE SOURCE AND CHASSIS

1. Power up the vehicle according to the vehicle owner's manual or manufacturer supplied information and verify the vehicle is in "ready mode".

2. Connect one lead of a multimeter with a high resistance (10 MΩ) to the electrical chassis and the other lead to the IPXXD probe.

    a. Probe each HV location with 1 ± 10% N of force until the probe contacts a HV part or until the probe cannot be pushed further. Do not allow the stop face to fully penetrate the EPB.
    b. If the probe partly or fully penetrates the EPB, probe the area in every possible orientation.
    c. Record all voltages measured on the appropriate data sheet.

3. If any voltages measured are greater than or equal to 60V DC or 30V AC, high voltage is present: continue to section 2.2.

2.2 DIRECT CONTACT BETWEEN HIGH VOLTAGE SOURCES

1. Power down the vehicle and HV system

    IMPORTANT: Before inspection, protect the area surrounding each location from step 2.1 that has HV present to prevent the probe from shorting HV to the vehicle chassis.

2. Connect one lead of a multimeter OR a low voltage supply with a continuity indicator to an exposed HV location and the other lead to the IPXXD probe.

    a. Probe each location from step 2.1 that has HV present
        i. Probe the area with 1 ± 10% N until the probe contacts a HV part or until the probe cannot be pushed further. Do not allow the stop face to fully penetrate the EPB.
        ii. If the probe partly or fully penetrates the EPB.
        iii. Document continuity measurements in the appropriate data sheet.

3. RESISTANCE EVALUATIONS (GTR 20 Section 6.1.4.)

3.1 RESISTANCE TESTER

1. Use a resistance tester with a current flow of at least 0.2 A and a resolution of at least 0.01 Ω for the following measurements.

2. Measure the resistance between the test location (component or connector) and the electrical chassis.

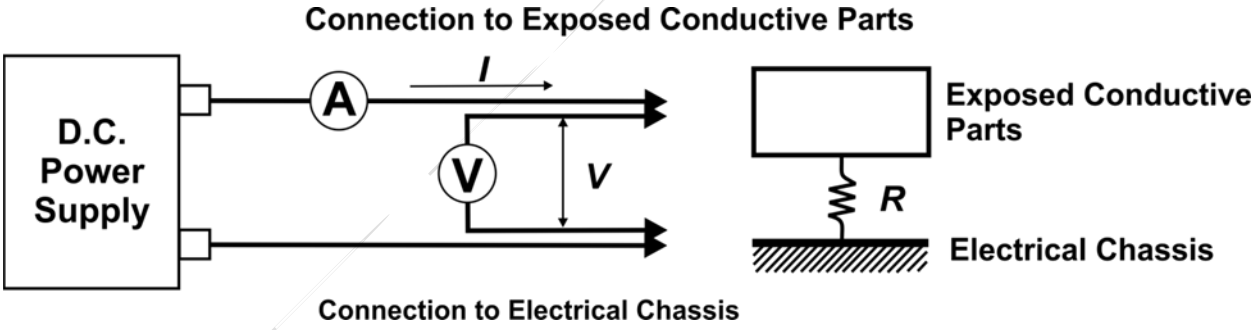
3. Measure the resistance between the test location and all other test locations which are within 2.5 meters of each other.

4. Repeat these measurements for all test locations which have not already met protection against indirect contact. Document all resistance measurements in the appropriate data sheet.

3.2 DC POWER SUPPLY

1. Use a DC power supply with a current flow of at least 0.2 A, a voltmeter with a resolution of at least 0.001 V, and an ammeter with a resolution of at least 0.01 A for the following measurements.

2. Connect the DC power supply, voltmeter and ammeter to the test location and the electrical chassis following figure:



3. Measure the current "I" and voltage "V" between the test location and the electrical chassis. Calculate the resistance between the test location and the electrical chassis using the following formula: R = V / I

4. Measure the current "I" and voltage "V" between the test location and all other test locations in Table 17 which are within 2.5 m of each other. Calculate the resistance between the test locations using the following formula: R = V / I

5. Repeat these measurements for all test locations which have not already met protection against indirect contact. Document all resistance measurements in the appropriate data sheet.

4. STANDARD CYCLE (GTR 20 Section 6.2.1.1.)

Information provided by the manufacturer shall include discharge procedure, charge procedure For cases where no information is provided by the manufacture the following will serve as a discharge/charge cycle.

1. Verify the ambient temperature is 20 ± 10 °C

2. Following the manufacturers recommendation on establishing a connection to the REESS

3. For discharging a REESS or RESSS subsystem, discharge the REESS at a rate specified by the manufacturer or at rate equal to the RESS amp-hour rating (1C).

    a. For discharging using a full vehicle, the discharge procedure will be defined by the manufacturer and the termination limit will be according to the vehicle controls.

4. Continue to discharge the REESS until the discharge limit specified by the manufacturer is reached.

5. Upon completion of the discharge, allow the REESS to rest for a minimum of 15 minutes.

6. Begin charging the REESS following the manufacturer's recommendation. For cases with no manufacturer provided recommendation of charge current use a rate equal to 1/3 the amp-hour rating (1/3C) of the REESS.

7. Continue charging the REESS until normally terminated.

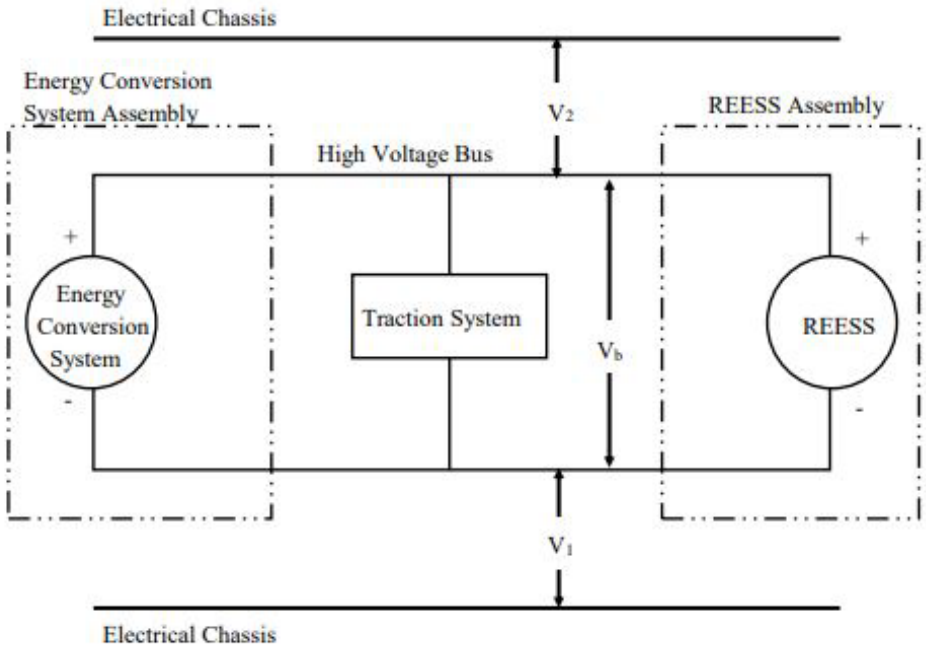
5. ISOLATION RESISTANCE MEASUREMENT (GTR 20 Section 6.1.1.)

IMPORTANT: Use caution throughout the isolation resistance measurement procedure and assume high voltage is present in the vehicle, use appropriate PPE.

1. For the following measurements ensure the voltmeter being used has an internal resistance of at least 10 MΩ.

2. Measure and record the high voltage bus voltage (Vb) as shown in Figure 2. Vb must be equal to or greater than the nominal operating voltage of the REESS and/or energy conversion system as specified by the vehicle manufacturer.

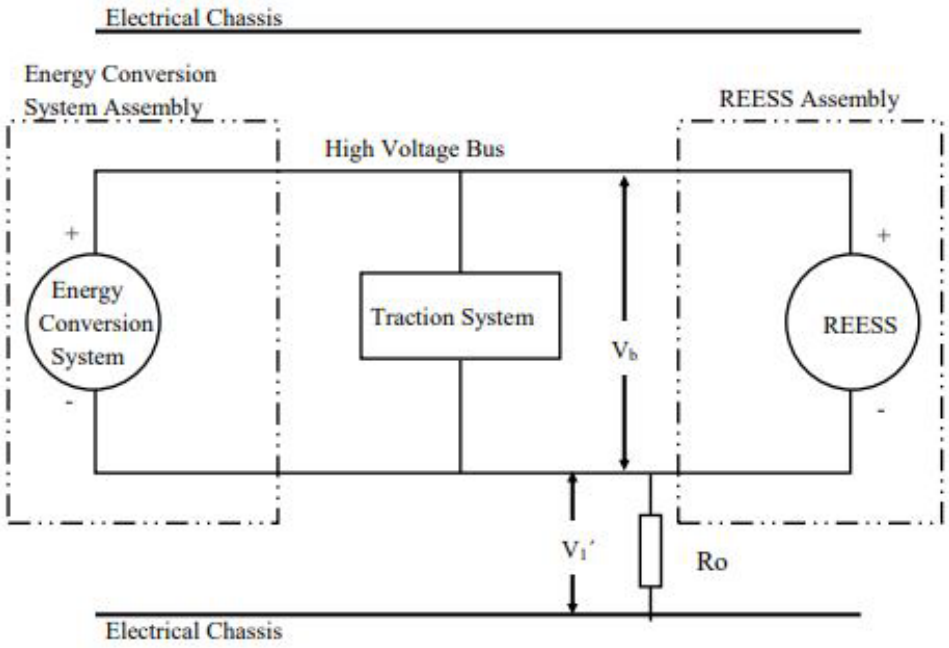
Figure 2
Measurement of V_b, V_1, V_2



3. Measure and record the voltage (V1) between the negative side of the high voltage bus and the electrical chassis and voltage (V2) between the positive side of the high voltage bus and the electrical chassis (see Figure 2).

4. If V1 is greater than or equal to V2, a standard known resistance (Ro) is inserted between the negative side of the high voltage bus and the electrical chassis. With Ro installed, measure the voltage (V1') between the negative side of the high voltage bus and the electrical chassis (see Figure 3).

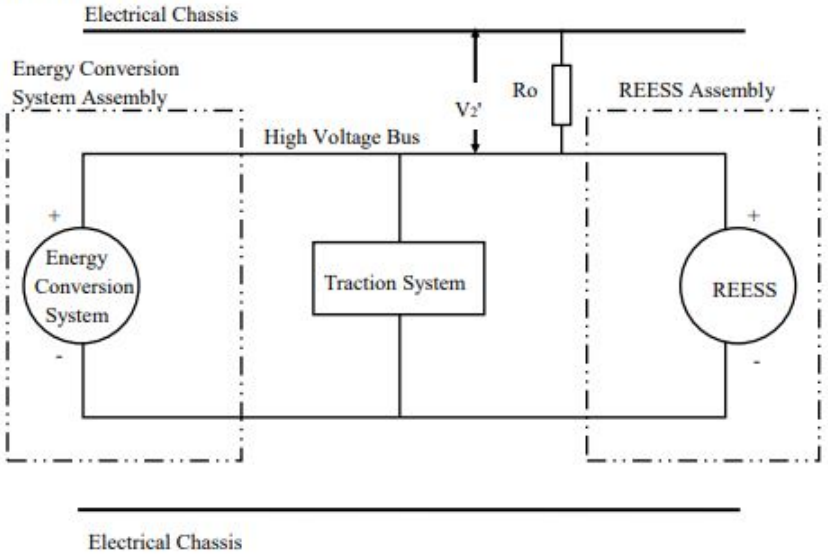
Figure 3
Measurement of V_1'



5. Calculate the electrical isolation (Ri) according to the following formula:
$Ri = Ro*(V_b/V_1' - V_b/V_1)$ or $Ri = Ro*V_b*(1/V_1' - 1/V_1)$

6. If V2 is greater than or equal to V1, a standard known resistance (Ro) is inserted between the positive side of the high voltage bus and the electrical chassis. With Ro installed, measure the voltage (V2') between the positive side of the high voltage bus and the electrical chassis (see Figure 4).

Figure 4
Measurement of V_2'



7. Calculate the electrical isolation (Ri) according to the following formula:
   $Ri = Ro*(V_b/V_2' - V_b/V_2)$ or $Ri = Ro*V_b*(1/V_2' - 1/V_2)$

8. Divide the electrical isolation value Ri (in Ω) by the working voltage of the high voltage bus (in V) to calculate the isolation resistance (in Ω/V).

Note 1: The standard known resistance Ro (in Ω) should be the value of the minimum required isolation resistance (in Ω/V) multiplied by the working voltage of the vehicle ± 20 per cent (in V). Ro is not required to be precisely this value because the equations are valid for any Ro; however, a Ro value in this range will provide good resolution for the voltage measurements.)

APPENDIX B
TEST DELIVERABLES AND REPORT GUIDELINES

APPENDIX B TEST REPORT AND DELIVERABLES GUIDELINES
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1. TEST DELIVERABLES AND REPORTING REQUIREMENTS

1.1 MONTHLY STATUS REPORTS

The contractor shall submit a Monthly Vehicle Status Report to the COR no later than the 15th day of each month following the month being reported on. The form can be found in **Section 3, Sheets**, in this appendix. The report shall be submitted until all vehicles or items of equipment are disposed of.

1.2 APPARENT TEST FAILURE

An apparent test failure, as described by Section 12 of the main test procedure, shall be communicated by telephone to the COR within 24 hours with written notification emailed within 48 hours (Saturday and Sundays excluded). A Laboratory Notice of Test Failure (located in **Section 3, Sheets**, of this appendix) with a copy of related test data sheet(s) and preliminary data and/or photographs shall be included.

In the event of a test failure, a post-test calibration check of some of the critically sensitive test equipment and instrumentation may be required for verification of accuracy. The necessity for the calibration shall be at the COR's discretion and shall be performed without additional costs to the Office of Crashworthiness Standards (OCWS).

1.3 TEST DELIVERABLES

Required deliverables for each test are discussed in this section. A Schedule of Deliverables is also provided at the end of this section.

A. QUICKLOOK REPORT

The Quicklook Report is a preliminary summary of the test that should be emailed to the OCWS within 24 hours of the test completion. The Quicklook Report should be updated after each REESS SAFETY – IN USE test and emailed within 24 hours of the test completion. The Quicklook Report should detail all relevant vehicle and test information. Anything interesting or out of the ordinary should be included in the Quicklook Report comments section. A sample Quicklook Report is included as **Sheet 5** in **Section 3** of this appendix.

B. QUALITY CONTROL PACKAGE

The Quality Control Package is a .zip file that includes all the information necessary for NHTSA's quality control review. It serves as a summary of the test and includes, organized by folders labelled appropriately:

- the test data (data tape)
  - per **Section 1.3, B** of this appendix
- photographs
  - labeled in order per **Section 2.3** of this appendix

- videos
  - real-time videos per **Section 9.1** of the main procedure
- a copy of the Quicklook Report previously emailed to the OCWS
  - per **Section 1.3, A** of this appendix

The Quality Control Package should be uploaded to the FTP site within five (5) business days of the test for review by the OCWS. Providing this data in a timely manner will ensure that the Contractor and the COR will be able to discuss the details of both test conduct and report content soon after the test is conducted. The filename for the Quality Control Package should be formatted as follows:

<NHTSANO><Model Year><Make & Model><Body> GTR 20 QCPackage.zip

C. PRELIMINARY (DRAFT) TEST REPORT

Contractors are required to submit to the OCWS via email a Draft Test Report, an electronic copy in .pdf form, within two calendar weeks of the test. If the electronic file is larger than 20 MB, the contractor should upload the file to the FPT site instead.

<NHTSANO><Model Year><Make & Model><Body> GTR 20 DraftReport.pdf

Contractors are required to review and proofread all rest reports before submittal to the COR. The OCWS will not act as a report quality control office for the contractors. Reports containing significant number of errors will be returned to the Contractor for correction and a hold will be placed on invoice payment for that test. The OCWS will alert the Contractor to any minimal corrections that should be made prior to submission of the Final Test Report.

D. FINAL TEST REPORT AND DELIVERABLES

The Final Test Report and associated documents, including test data, properly labeled and numbered photographs and videos, are relied upon as the chronicle of the test. Each Final Test Report should also be a complete document capable of standing by itself.

The Final Test Report and associated deliverables will be released to the public domain after review and acceptance by the COR. For these reasons, all deliverables must be complete and error-free. Final Test Reports containing errors will be returned to the Contractor for correction and a hold will be placed on the invoice for payment.

NOTE: Only those photos required in the Final Test Report, as set forth in this procedure, shall be included unless the OCWS requests the inclusion of additional photos to document specific test events or anomalies.

The Contractor shall upload the Final Test Report and final versions of the associated test data, photos and videos as a .zip file to the FTP site within two (2) weeks of receiving data tape and Draft Test Report corrections from the OCWS. The format for its filename should be as follows:

<NHTSANO><Model Year><Make & Model><Body> GTR 20 FinalDeliverables.zip

The following is a summary of all test deliverable requirements:

Test Deliverable	**Section of Appendix**	**File Format & Naming Convention**	**Time Requirement**	**Submit Via**	**Submit To**
Quicklook Report	1.3, A	.pdf with filename format: <NHTSANO> <Model Year> <Make & Model><Body> GTR 20 Quicklook.pdf	One (1) day from test To be updated and sent after each REESS SAFETY – IN USE test	Email	OCWS
Quality Control Package	1.3, B	.zip with filename format: <NHTSANO> <Model Year> <Make & Model><Body> GTR 20 QCPackage.zip	Five (5) business days from test series completion	FTP	FTP
Preliminary (Draft) Test Report	1.3, C	.pdf with filename format: <NHTSANO> <Model Year> <Make & Model><Body> GTR 20 DraftReport.pdf	Two (2) weeks from test series completion	Email/FTP (depending on file size)	OCWS/FTP
Final Test Report and Deliverables	1.3, D	.zip with filename format: <NHTSANO> <Model Year> <Make & Model><Body> GTR 20 FinalDeliverables.zip	Two (2) weeks after receiving corrections to preliminary test report	FTP	FTP

F. TEST REPORT REQUIREMENTS

The Final Test Report and associated documentation (including photographs and videos) is relied upon as the chronicle of the test. The final documentation and data will be released to the public domain after review and acceptance by the COR. For these reasons, each Final Test Report must be a complete document capable of standing by itself.

Instructions for the preparation of the first three pages of the final test report are provided below for standardization purposes.

G. FIRST THREE PAGES

1. Front Cover – The information required on the cover is as follows:

   a. Final Report Number, such as GTR20-ABC-XX-001

      where

GTR20	is the test
ABC	are the initials for the laboratory
XX	are the last two digits of the fiscal year of the test program
001	is the test number for that fiscal year (001 for the 1st test conducted in the fiscal year, 002 for the 2nd test, 003 for the 3rd test, etc.)

   b. Final Report Title and Subtitle, such as

      National Highway Traffic Safety Administration
      (NHTSA)
      GTR 20 Electric Vehicle Safety Tests
      ****
      World Motors Corporation
      20XX XYZ 4-Door Sedan
      NHTSA No. CX401

   c. Contractor's Name and Address, such as

      XYZ TESTING LABORATORIES, INC.
      4335 West Dearborn Street
      Detroit, Michigan 48090

NOTE: DOT SYMBOL WILL BE PLACED BETWEEN ITEMS (c) and (d)

   d. Date of Final Report completion

   e. The words "FINAL REPORT"

f. The sponsoring agency's name and address as follows:

U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crashworthiness Standards
1200 New Jersey Ave, SE
Room W43-410
Washington, DC 20590

2. First Page After Front Cover – A disclaimer statement and an acceptance signature block for the COR shall be provided as follows:

This publication is distributed by the U.S. Department of Transportation, National Highway Traffic Safety Administration, in the interest of information exchange. The opinions, findings and conclusions expressed in this publication are those of the author(s) and not necessarily those of the Department of Transportation or the National Highway Traffic Safety Administration. The United States Government assumes no liability for its contents or use thereof. If trade or manufacturers' names or products are mentioned, it is only because they are considered essential to the object of the publications and should be not construed as an endorsement. The United States Government does not endorse products or manufacturers.

Prepared by:_____
Approved by:_____
Approval Date:_____

FINAL REPORT ACCEPTANCE BY OCWS:

_____

_____
COR, New Car Assessment Program
NHTSA, Office of Crashworthiness Standards

Date:_____

3. Second Page After Front Cover – A completed Technical Report Documentation Page (Form DOT F1700.7) shall be completed for those items that are applicable with the other spaces left blank. Sample data for the applicable block numbers of the title page follows:

Block No. 1 – REPORT NO.

GTR20-ABC-XX-001

Block No. 2 – GOVERNMENT ACCESSION NUMBER

Leave blank

Block No. 3 – RECIPIENT'S CATALOG NUMBER

Leave blank

Block No. 4 – TITLE AND SUBTITLE

Final Report of GTR20 Testing
of a 20XX World XYZ Deluxe 4-Door Sedan
NHTSA No. MX20XXXXXX

Block No. 5 – REPORT DATE

March 1, 20XX

Block No. 6 – PERFORMING ORGANIZATION CODE

ABC

Block No. 7 – AUTHOR(S)

John Smith, Project Manager
Bill Doe, Project Engineer

Block No. 8 – PERFORMING ORGANIZATION REPORT NUMBER

GTR20-ABC-XX-001

Block No. 9 – PERFORMING ORGANIZATION NAME AND ADDRESS

ABC Laboratories
405 Main Street
Detroit, MI 48070

Block No. 10 – WORK UNIT NUMBER

Leave black

Block No. 11 – CONTRACT GRANT NUMBER

DTNH22-XX-D-1 2345

Block No. 12 – SPONSORING AGENCY NAME AND ADDRESS

US Department of Transportation
National Highway Traffic Safety Administration
Office of Crashworthiness Standards
1200 New Jersey Ave SE
Washington, DC 20590

Block No. 13 – TYPE OF REPORT AND PERIOD COVERED

Final Test Report
Feb. 15 to Mar. 15, 20XX

Block No. 14 – SPONSORING AGENCY CODE

NRM-110

Block No. 15 – SUPPLEMENTARY NOTES

Leave blank

Block No. 16 – ABSTRACT

Electric Vehicle GTR 20 evaluations were conducted on the subject 2019 Chevrolet Bolt EV LT 5-Door Hatchback in accordance with the specifications of the Electric Vehicle Safety GTR sections:

- 5.1.1 – Protection against electric shock
- 5.1.2 – Functional Safety
- 5.3.2 – Warning in the event of operational failure of vehicle controls that manage REESS safe operation
- 5.3.3 – Warning in the case of a thermal event within the REESS
- 5.3.4 – Warning in the event of low energy content of REESS
- 5.4.5 – External short circuit protection
- 5.4.6 – Overcharge protection
- 5.4.7 – Over-discharge protection
- 5.4.8 – Over-temperature protection
- 5.4.9 – Overcurrent protection

Block No. 17 – KEYWORDS

GTR 20
Electric Vehicle Safety

Block No. 18 – DISTRIBUTION STATEMENT

Copies of this report are available from the following:

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Technical Information Services Division, NPO-411
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Block No. 19 – SECURITY CLASSIFICATION OF REPORT

Unclassified

Block No. 20 – SECURITY CLASSIFICATION OF PAGE

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Block No. 21 – NO. OF PAGES

Add appropriate number

Block No. 22 – PRICE

Leave blank

2. SAMPLE TEST REPORT LAYOUT

Draft and final test reports shall have the following layout for standardization purposes:

Section		Page No.
1	Purpose of the Test	X
2	Summary of the Test Results	X
3	Vehicle Information / Data Sheets	X

Data Sheet No.		Page No.
1	Test Vehicle Specifications	X
2	Protection Against Electrical Shock	X
3	Functional Safety	X
4	Functionality of REESS in a Vehicle	X
5	External Short Circuit Protection	X
6	Overcharge Protection	X
7	Over-Discharge Protection	X
8	Over-Temperature Protection	X
9	Overcurrent Protection	X

Appendix		Page No.
A	Photographs	AX
B	Data Traces	BX
C	Test Equipment and Instrumentation Calibration	CX

2.1 REPORT AREA 1: PURPOSE AND SUMMARY OF TEST

PURPOSE

This area briefly outlines the purpose for conducting the test and states the appropriate test procedure followed during the test. The following language is provided as an example:

Electric Vehicle GTR 20 "in-use" Evaluations were conducted on the subject <Model Year><Make & Model><Body Style>. The following evaluation were conducted:

- *5.1.1 – Protection against electric shock*
- *5.1.2 – Functional Safety*
- *5.3.2 – Warning in the event of operational failure of vehicle controls that manage REESS safe operation*
- *5.3.3 – Warning in the case of a thermal event within the REESS*
- *5.3.4 – Warning in the event of low energy content of REESS*
- *5.4.5 – External short circuit protection*
- *5.4.6 – Overcharge protection*
- *5.4.7 – Over-discharge protection*
- *5.4.8 – Over-temperature protection*
- *5.4.9 – Overcurrent protection*

These evaluations were conducted in accordance with the Electric Vehicle GTR 20 Procedure, dated September 7, 20XX to determine compliance to the requirements of Draft Global Technical Regulation (GTR) No.020 on Electric Vehicle Safety.

SUMARRY

Electric Vehicle GTR 20 "in-use" Evaluations were performed by XYZ Laboratories on a <Model Year><Make & Model><Body Style> on <Date>. The vehicle was evaluated for protection against electrical shock and functional safety. The REES was evaluated for functionality and safety in-use.

Based on the test results, <Model Year><Make & Model><Body Style>appears to meet the requirements for the evaluations that were conducted.

Data sheets, along with pre-test and post-test photographs, are included in this report to document the test.

2.2 REPORT AREA 2: DATA SHEETS

Data sheets can be found in **Section 3** of this appendix. For purposes of consistency, it is highly suggested that exact replicas of these sheets are inserted into the Final Test Report. The Contractor may expand upon the data sheets if desired; however, the data must be presented in the order listed under the above “SAMPLE TEST REPORT LAYOUT”. Any additional inclusions MUST be placed **after** the required sheets.

2.3 REPORT AREA 3: PHOTOGRAPHIC DOCUMENTATION (TEST REPORT APPENDIX A)

The following photographs should be included as Appendix A of the final test report, two photos per page. A vehicle information placard, identifying the test vehicle, test date, and NHTSA number, along with an indication of whether the photo was taken pre-test or post-test, shall clearly appear in each photograph. In cases where it may be unreasonable to include this long form placard, an indication of NHTSA number should suffice. A time/date stamp on each photo is also highly recommended.

The following photographs should be included with the Quality Control Package and labeled as indicated. The text in parenthesis is for clarification purposes only and **need not be included**.

Additional photographs which further describe what is visible in Photograph Nos. 1 – XX should be labeled with the most relevant photograph number followed by a, b, c, etc.

For example, if the laboratory would like to provide more than one photograph of

027 – Pre-test view of … (required photo)
027a – Pre-test view of … (additional view)

Any additional photographs taken for documentation of vehicle anomalies, safety concerns, test details, etc. which do not fit under the photograph descriptions above should be appropriately labeled and shall follow the list of preceding required photographs in numerical order.

No. 01	As Delivered Right Front ¾ View of Test Vehicle
No. 02	As Delivered Left Rear ¾ View of Test Vehicle
No. 03	External Vehicle Charger
No. 04	Vehicle Occupant Compartment
No. 05	Vehicle Occupant Compartment with Components Removed
No. 06	Vehicle Luggage Compartment
No. 07	Vehicle Luggage Compartment with Components Removed
No. 08	Vehicle Manual Safety Disconnect Installed in Vehicle
No. 09	Vehicle Manual Safety Disconnect Removed from Vehicle
No. 10	Momentary Indication When Placed in Active Driving Mode
No. 11	Driver Leaving the Vehicle Indication
No. 12	Momentary Signal to Driver When Selecting Active Drive Mode While External Charging is Active.

No. 13 Low Energy Warning to the Driver

No. 14 External Short Circuit Breakout Harness

No. 15 External Short Circuit Test Setup

No. 16 External Short Circuit Vehicle – Post Test

No. 17 Overcharge Breakout Harness

No. 18 Overcharge Test Setup

No. 19 Overcharge Vehicle – Post Test

No. 20 Over-discharge Breakout Harness

No. 21 Over-discharge Test Setup

No. 22 Over-discharge Vehicle – Post Test

No. 23 Over-temperature Breakout Harness

No. 24 Over-temperature Test Setup

No. 25 Over-temperature Vehicle – Post Test

No. 26 Overcurrent Breakout Harness

No. 27 Overcurrent Test Setup

No. 28 Overcurrent Vehicle – Post Test

2.4 REPORT AREA 4: DATA TRACES (TEST REPORT APPENDIX B)

The following data traces should be included as Appendix B of the Final Test Report:

External Short Circuit

- REESS Voltage
- REESS Current
- REESS Temperature
- Short Circuit Current

Overcharge Protection

- REESS Voltage
- REESS Current
- REESS Temperature
- Overcharge Voltage
- Overcharge Current
- Overcharge Power

Over-discharge Protection

- REESS Voltage
- REESS Current
- REESS Temperature
- Over-discharge Voltage
- Over-discharge Current
- Over-discharge Power

Over-temperature Protection

- REESS Voltage
- REESS Current
- REESS Temperature
- Vehicle Drive Profile (if used)
- Charge Voltage (if used)
- Charge Current (if used)

Overcurrent Protection

- REESS Voltage
- REESS Current
- REESS Temperature
- Overcurrent Voltage
- Overcurrent Current
- Overcurrent Power
- Environmental Chamber Temperature

2.5 REPORT AREA 5: TEST EQUIPMENT AND INSTRUMENTATION CALIBRATION (TEST REPORT APPENDIX C)

APPENDIX C should identify all test equipment and sensors to collect data during the tests. Calibration dates for each should be provided and comments should also be included, if appropriate.

3. DATA SHEETS

Data sheets are provided as tools to document test data in the final test report format as outlined in Section 2 of this appendix. The Contractor is not restricted from using other tools or expanding the data sheets provided in this section. Nevertheless, for consistency and uniformity in reporting data, the Contractor must present, at a minimum, all information in the following Data Sheets in the Final Test Report. This data must be presented in the order outlined in Section 1 of this Appendix.

DATA SHEET NO. 1
TEST VEHICLE SPECIFICATIONS

Test Vehicle: _____ NHTSA No.: _____

TEST VEHICLE INFORMATION

Year/Make/Model/Body Style	
NHTSA No.	
Color	
Odometer Reading	

DATA FROM CERTIFICATION LABEL

Manufactured By	
Date of Manufacture	
VIN:	

GVWR (kg)	
GAWR Front (kg)	
GAWR Rear (kg)	

ELECTRIC VEHICLE PROPULSION SYSTEM

Type of Electric Vehicle (Electric/Hybrid):	
Electric Energy Storage/Device:	
Nominal Voltage (V):	
Is this vehicle equipped with an Automatic Propulsion Battery Disconnect?	
Physical Location of the Automatic Propulsion Battery Disconnect:	
Auxiliary Battery Type:	

DATA SHEET NO. 1 (CONTINUED)
TEST VEHICLE SPECIFICATIONS

Test Vehicle: _____ NHTSA No.: _____

ELECTRIC ENERGY STORAGE CONVERSION/DEVICE SYSTEM DATA (COTR SUPPLIED)

Electrolyte Fluid Type:		
Electrolyte Fluid Specific Gravity:		
Electrolyte Kinematic Viscosity:		
Electrolyte Fluid Color:		
Electric Energy Storage/Conversion System Coolant Type, Color, Specific Gravity (if applicable):		
Location of Battery Modules:		Inside Passenger Compartment
		Outside Passenger Compartment
	.	

ELECTRIC ENERGY STORAGE CONVERSION/DEVICE STATE OF CHARGE

For all battery types:	
Voltage range corresponding to **useable energy** of the battery:	
Minimum State of Charge:	
Maximum State of Charge:	
95% of Maximum State of Charge:	
For batteries that are rechargeable ONLY by an energy source on the vehicle:	
Voltage range corresponding to **useable energy** of the battery:	
Minimum State of Charge:	
Maximum State of Charge:	

DATA SHEET NO. 2
PROTECTION AGAINST ELECTRICAL SHOCK

Test Vehicle: _____ NHTSA No.: _____

PROTECTION AGAINST DIRECT CONTACT

PASSENGER AND LUGGAGE COMPARTMENT

Applicable HV Locations Present: **YES/NO** (if YES fill out table below)

HV Location	Voltage	Continuity

AREAS OTHER THAN THE PASSENGER AND LUGGAGE COMPARTMENT

Applicable HV Locations Present: **YES/NO** (if YES fill out table below)

HV Location	Voltage	Continuity

DATA SHEET NO. 2 (CONTINUED)
PROTECTION AGAINST ELECTRICAL SHOCK

Test Vehicle: _____ NHTSA No.: _____

SERVICE DISCONNECT

HV Location	Voltage	Continuity

MARKINGS

HV Location	Marking	Orange Cover

DATA SHEET NO. 2 (CONTINUED)
PROTECTION AGAINST ELECTRICAL SHOCK

Test Vehicle: _____ NHTSA No.: _____

PROTECTION AGAINST INDIRECT CONTACT

Applicable HV Locations Present: **YES/NO** (if YES fill out table below)

HV Location	Connection	Resistance

Applicable HV Locations < 2.5 m Apart Present: **YES/NO** (if YES fill out table below)

HV Location 1	HV Location 2	Resistance

DATA SHEET NO. 2 (CONTINUED)
PROTECTION AGAINST ELECTRICAL SHOCK

Test Vehicle: _____ NHTSA No.: _____

GROUNDED EXTERNAL CHARGING

External Power Supply Grounding Method	

ISOLATION RESISTANCE – DC BUS

Measurement	Value	Isolation
Vb		
V1		
V2		
V1’		
V2’		
Ro		
Working Voltage		

ISOLATION RESISTANCE – AC BUS

Measurement	Value	Isolation
Vb		
V1		
V2		
V1’		
V2’		
Ro		
Working Voltage		

DATA SHEET NO. 2 (CONTINUED)
PROTECTION AGAINST ELECTRICAL SHOCK

Test Vehicle: _____ NHTSA No.: _____

ISOLATION MONITORING SYSTEM FOR FUEL CELL VEHICLES

Calculated Isolation Resistance	Resistor	Indication to Driver

ISOLATION RESISTANCE – EXTERNAL AC CHARGING

Measurement	Value	Isolation
Vb		
V1		
V2		
V1’		
V2’		
Ro		
DC Working Voltage		
AC Working Voltage		

DATA SHEET NO. 3
FUNCTIONAL SAFETY

Test Vehicle: _____ NHTSA No.: _____

MOMENTARY INDICATION WHEN PLACED IN ACTIVE DRIVING MODE

Internal Combustion Engine Provides Propulsion Power Upon Startup:
YES/NO (if NO fill out table below)

Drive Mode Selection	Momentary Indication Description
Startup	
Drive / Forward	
Reverse	

DRIVER TO BE INFORMED WHEN LEAVING VEHICLE

Driver Can Leave Vehicle While In Active Driving Mode: **YES/NO** (if YES fill out table below)

Drive Mode Selection	Momentary Indication Description
Drive / Forward	
Reverse	

DATA SHEET NO. 3 (CONTINUED)
FUNCTIONAL SAFETY

Test Vehicle: _____ NHTSA No.: _____

STATE OF DRIVE DIRECTION IDENTIFICATION

Drive Mode Selection	Momentary Indication Description
Drive / Forward	
Reverse	

VEHICLE MOVEMENT WHILE EXTERNALLY CHARGING

Vehicle Equipped with External Charging: **YES** (if YES fill out table below for each charger type)

Part Number: 24291478 (120V, 60 Hz, 12A, 1440W AC Charger)

Drive Mode Selection	Vehicle Movement
Drive / Forward	
Reverse	

Drive Mode Selection	Vehicle Movement
Drive / Forward	
Reverse	

Drive Mode Selection	Vehicle Movement
Drive / Forward	
Reverse	

DATA SHEET NO. 4
FUNCTIONALITY OF REESS IN A VEHICLE

Test Vehicle: _____ NHTSA No.: _____

WARNING IN THE EVENT OF OPERATIONAL FAILURE OF VEHICLE CONTROLS THAT MANAGE THE SAFE OPERATION OF THE REESS

Description of Warning to the Driver	

WARNING IN THE EVENT OF A THERMAL EVENT WITHIN THE REESS

Description of Warning to the Driver	

WARNING IN THE EVENT OF LOW ENERGY CONTENT OF REESS

Description of Warning to the Driver	

DATA SHEET NO. 5
EXTERNAL SHORT CURCUIT

Test Vehicle: _____ NHTSA No.: _____

EXTERNAL SHORT CIRCUIT SETUP

Test Setup Notes	

ISOLATION RESISTANCE – EXTERNAL SHORT CIRCUIT

Measurement	Value	Isolation
Vb		
V1		
V2		
V1’		
V2’		
Ro		
DC Working Voltage		
AC Working Voltage		

EXTERNAL SHORT CIRCUIT OBSERVATIONS

Post Test Observations	

DATA SHEET NO. 6
OVERCHARGE PROTECTION

Test Vehicle: _____ NHTSA No.: _____

OVERCHARGE PROTECTION SETUP

Test Setup Notes	

ISOLATION RESISTANCE – EXTERNAL SHORT CIRCUIT

Measurement	Value	Isolation
Vb		
V1		
V2		
V1’		
V2’		
Ro		
DC Working Voltage		
AC Working Voltage		

OVERCHARGE PROTECTION OBSERVATIONS

Post Test Observations	

DATA SHEET NO. 7
OVER-DISCHARGE PROTECTION

Test Vehicle: _____ NHTSA No.: _____

OVER-DISCHARGE PROTECTION SETUP

Test Setup Notes	

ISOLATION RESISTANCE – EXTERNAL SHORT CIRCUIT

Measurement	Value	Isolation
Vb		
V1		
V2		
V1’		
V2’		
Ro		
DC Working Voltage		
AC Working Voltage		

OVER-DISCHARGE PROTECTION OBSERVATIONS

Post Test Observations	

DATA SHEET NO. 8
OVER-TEMPERATURE PROTECTION

Test Vehicle: _____ NHTSA No.: _____

OVER-TEMPERATURE PROTECTION SETUP

Test Setup Notes	

ISOLATION RESISTANCE – EXTERNAL SHORT CIRCUIT

Measurement	Value	Isolation
Vb		
V1		
V2		
V1’		
V2’		
Ro		
DC Working Voltage		
AC Working Voltage		

OVER-TEMPERATURE PROTECTION OBSERVATIONS

Post Test Observations	

DATA SHEET NO. 9
OVERCURRENT PROTECTION

Test Vehicle: _____ NHTSA No.: _____

OVERCURRENT PROTECTION SETUP

Test Setup Notes	

ISOLATION RESISTANCE – EXTERNAL SHORT CIRCUIT

Measurement	Value	Isolation
Vb		
V1		
V2		
V1’		
V2’		
Ro		
DC Working Voltage		
AC Working Voltage		

OVERCURRENT PROTECTION OBSERVATIONS

Post Test Observations	

4. PRE-TEST SHEETS

Pre-test sheets are provided as tools to use in the exchange of data between the COR and the Contractor. These pre-test sheets are not part of the Final Test Report. The Contractor is not restricted from using other tools or expanding the sheets outlined in this section.

A. SHEET 1 – Test Vehicle Information

A "Test Vehicle Information" form will be supplied, either by the purchasing Contractor or the COR, to the Contractor before testing preparation. Information on this form is supplied by the automobile manufacturer to aid in the initial test setup and shall be considered as reference material.

TEST VEHICLE INFORMATION FOR HYBRID AND ELECTRIC VEHICLES
(for GTR 20)

Vehicle Model Year and Make: _____

Vehicle Model and Body Style: _____

Please provide instructions via electronic link or attachment that may be useful or necessary in relation to GTR 20 in preparing the battery system and/or vehicle pre-test, executing the tests, performing assessment of the battery system and/or vehicle post-test (including handling instructions), and battery discharge instructions.

ELECTRONIC VEHICLE PROPULSION SYSTEM:

Type of Electric Vehicle Propulsion (Electric/Gas-Electric Hybrid/Fuel Cell-Electric Hybrid):

_____

Propulsion Battery Type: _____

Nominal Voltage: _____ V

Is this vehicle equipped with an Automatic Propulsion Battery Disconnect?

☐ YES ☐ NO

Physical Location of Automatic Propulsion Battery Disconnect? _____

Auxiliary Battery Type: _____

PROPULSION BATTERY SYSTEM DATA:

Electrolyte Fluid Type: _____

Electrolyte Fluid Specific Gravity: _____

Electrolyte Fluid Kinematic Viscosity: _____

Electrolyte Fluid Color: _____

Propulsion Battery Coolant: _____

Propulsion Battery Coolant Color (if applicable): _____

Location of Battery Modules (Check location)**:**

☐ Inside Passenger Compartment

☐ Outside Passenger Compartment

Propulsion Battery State of Charge:

☐ Maximum State of Charge: _____ V

-OR-

☐ Range of Normal Operating Voltage: _____ V

Provide step-by-step instructions on how to charge the propulsion battery system to the level specified in (1), (2), or (3) below **along with how to verify condition is met**:

1. The voltage corresponding to the maximum state of charge recommended by the manufacturer, as stated in the vehicle's owner's manual or on a label that is permanently affixed to the vehicle;

-OR-

2. If the manufacturer has made no recommendation, a voltage corresponding to a state of charge of not less than 95 percent of the maximum capacity of the battery system;

-OR-

3. If the batteries are rechargeable only by an energy source on the vehicle, how to operate the vehicle such that the maximum practicable state of charge within the normal operating range, as specified by the manufacturer, is reached as indicated by the vehicle's instrumentation, if installed, or using other measurement methods.

_____

VEHICLE CHASSIS GROUND POINT(S) LOCATION(S):

What is the recommended chassis ground point(s) & location(s) for measurement of electrical isolation? Attach necessary documentation.

_____

_____

_____

PROPULSION BATTERY SYSTEM:

What are the recommended positive and negative measurement points for automatic disconnect and propulsion battery? Attach necessary documentation.*

_____

_____

_____

_____

What is the recommended method for attaching test leads to measurement points? Attach necessary documentation.*

_____

_____

* Attach .pdf of First Responder's manual or Service Manual (or website link to information), if applicable.

SPECIAL INSTRUCTIONS, HAZARDS, AND PRECAUTIONS:

Provide any special instructions, hazards, and precautions while working on the vehicle:

_____

_____

_____

_____

Also provide a current Material Safety Data Sheet (MSDS) for the battery and any other hazardous components.

GROUNDED EXTERNAL CHARGING:

Provide any drawings or materials to support compliance of GTR 20 section 5.1.1.2.3:

_____

_____

_____

EXTERNAL CHARGING SYSTEMS (IF APPLICABLE):

Provide part numbers and specifications of all external charging options:

_____

_____

_____

WARNING INDICATION TO THE DRIVER:

Provide a description of the warning to the driver in the event of operational failure of REESS safety controls in compliance of GTR 20 section 5.4.12.1:

_____

_____

_____

Provide a description of the warning to the driver in the event of a thermal event within the REESS:

_____

_____

_____

Provide a description of the warning to the driver in the event of low energy content of the REESS:

_____

_____

_____

STANDARD CYCLE:

Provide discharge rate and procedure for a standard cycle (including end voltage):

_____

_____

_____

REESS TEMPERATURE MONITORING:

Provide a procedure for monitoring the temperature of the REESS during testing:

_____

_____

_____

EXTERNAL SHORT CIRCUIT:

Provide a breakout harness along with installation instructions for short circuit testing in GTR 20 section 5.4.5:

_____

_____

_____

OVERCHARGE:

Provide a breakout harness along with installation instructions for overcharge testing. Provide maximum charge current and voltage limit of the tested device, and the maximum operating temperature of the REESS in GTR 20 section 5.4.6:

_____

_____

_____

OVER-DISCHARGE:

Provide a breakout harness along with installation instructions for over-discharge testing. Provide the maximum discharge rate or choose to use a 1 kW resistor in GTR 20 section 5.4.7:

_____

_____

_____

OVER-TEMPERATURE:

Provide a procedure for disabling the REESS cooling system to the extent possible while maintaining REESS operation in GTR 20 section 5.4.8:

_____

_____

_____

OVERCURRENT:

Provide a breakout harness along with installation instructions for overcurrent testing. Provide maximum current and voltage of the external DC supply equipment, and the maximum normal operating charging current of the external DC supply equipment in GTR section 5.4.9:

_____

_____

_____